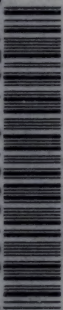


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BLIGHTS OF THE WHEAT,

AND

THEIR REMEDIES.

“I have smitten you with blasting and mildew: when your gardens and your vineyards and your fig trees and your olive trees increased, the palmer worm devoured them: yet have ye not returned unto me, saith the Lord.”—AMOS iv. 9.

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PREFACE.

HAVING, during a long residence in one of the principal agricultural districts of Norfolk, been in the habit of examining in my walks the various blights of the corn plants in all their stages, I have been often requested to make known my observations in a popular form. In arriving at conclusions on these subjects, and in bringing them on certain occasions before assemblages of scientific men, I have been most materially assisted by professor Henslow, and the Rev. I. M. Berkeley, to whom I desire to acknowledge my obligations. Nor are there two higher authorities to be found. In complying with the request that I would publish a plain treatise on these curious subjects, it gives me real satisfaction that it should come out through the medium of the Religious Tract Society, which has so admirably continued

the advancement of popular science with its highest and best end, the manifestation of His glory who gave us both the book of nature and that of revelation.

EDWIN SIDNEY.

Acle, near Norwich, June 22, 1846.

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BLIGHTS OF THE WHEAT.

CHAPTER I.

Importance of the subject—Prevalent ignorance respecting it, and consequences—Anxiety of the agriculturists for the aid of science—Providential checks to the ravages of the corn-pests—Remarks—The wonders revealed respecting these minute enemies of the wheat, by the microscope—Parasites—Fungi—Their botanical character—Their normal mode of germination and growth—Their various forms—The orders into which they seem capable of being reduced—The names of these orders explained—Properties of fungi—Their places of growth—Speculations concerning them—Why called the scavengers of nature—Exceptions—Question as to the conditions of their development—Wonderful instance of an animal being replaced by a fungus—Analogy from this retrograde step in creation—Mycelium defined and described—Plan of this volume.

THE preservation and purity of the flour of wheat will be universally acknowledged to be matters of the highest importance; but the methods by which these objects may be attained, are much more dependent on an accurate knowledge of certain extremely minute devastators of the growing crops, than has been hitherto generally conceived. Those persons whose province it is to cultivate and reap

our wheat fields, have unfortunately not been properly informed as to the real nature of the little pests from which they have suffered. The consequence of this has been a large destruction of food, and a frequent deterioration of that which has been saved. In the year 1841, the absence of this essential knowledge amongst farmers was clearly demonstrated. A prize was offered by the Agricultural Society of England for the best essay on the blights affecting the corn fields, but though many were sent in, not one was deemed meritorious. By a similar want of physical science the inquiries of a large provincial association into the habits of the turnip fly were rendered totally useless, because they were not first directed to the natural history of the insect. Such investigations have been principally the task of learned botanists and entomologists, whose statements have failed to elicit the general attention they deserved. Unscientific persons have been repelled from the task of carefully perusing them, by their difficulty in understanding the technical terms necessarily employed by the authors. From such sources, however, they can alone derive the information that will lead to satisfactory results, and every agriculturist, who has the

opportunity, ought to endeavour to make himself sufficiently master of the elementary knowledge needful to this end. It is by these means alone that he can hope to rise to real excellence in carrying on his interesting avocations, as well as to escape the ill effects of many, to him, inexplicable contingencies by which he finds himself constantly thwarted. Happily the British farmer has lately been awakened to the advantages afforded him in the laboratory of nature, by the guidance of true philosophy. The period, therefore, seems to have arrived when a popular treatise descriptive of the secrets which the microscope unfolds to the scientific observer, with regard to the hitherto mysterious destroyers of the wheat plant, will be both acceptable and useful to this valuable portion of our community, as well as to the public at large.

These little ravagers of our growing crops of corn are amongst the most wonderful of living organized things; and although they inflict unspeakable damage under certain circumstances, their existence, as we shall hereafter notice, embodies great and often beneficent designs. They also call forth the exercise of human ingenuity in the investigation of their habits, and the prevention of the mischiefs

they occasion. These mischiefs are not unfrequently checked in most striking ways by the great Author of nature himself, and afford the strongest assurance to the reflecting mind that he ever mingles mercy with judgment. A multitude of mysterious evils encompasses all that is accorded to man in this imperfect state of his existence, but there is not one, material or spiritual, for which an effectual antagonism may not be found if sought for aright. Still it must be remembered that much of what is received as common truth on these points, is nothing more than common error. This is equally the case in religion, in philosophy, in morals, and in science. Every endeavour to correct and inform on sound principles, however humbly it may be made, is to be regarded as worthy of attention ; and we may be assured that not a single creature has been formed by the hand of God, that is not deserving of the attention of a reasonable mind. For want of such inquiry we have suffered much both in actual injury, as well as in the non-acquirement of that knowledge which tends to exalt the faculties of our understandings, and leads to adoration of the great supreme Cause, as much the object of our admiration in

what seems only an organized atom, as in the more visible living works of greater dimensions. Whatever escapes the unassisted eye of man is often treated with indifference, but there is not a thing formed on which there is not stamped the seal of omnipotence and infinite wisdom—

Shall little haughty ignorance pronounce
His works unwise, of which the smallest part
Exceeds the narrow vision of her mind?
As if upon a full-proportioned dome,
Of swelling columns reared, the pride of art,
A critic fly, whose feeble ray scarce spreads
An inch around, with blind presumption bold
Should dare to tax the structure of the whole.

THOMSON.

The natural perfections of God are set before us for our admiration, the moral for our imitation. The book of nature answers our questions as regards the former; the book of revelation as to the latter. They harmonize with each other. In the subjects of this treatise we have a most prominent example of the importance of research, both as regards the avoidance of evil and the manifestation of creative wonders. The promised harvests of our fields droop beneath the corrosive influences of minute agencies, multiplied till they become at

times almost overwhelming. Their forms, their sources, the principles upon which they can by any possibility aid in the economy of the world seem alike, at first, undefinable. So do their remedies. Masses of dark unwholesome blights blast the growing plants in our corn-fields, and infect our granaries. To the common observer they appear shapeless and disgusting ; but the eye of science has penetrated their secret nature, and beholds, in their exquisite organism, incredible reproductive power, and, under circumstances of a peculiar kind, uses. Besides, we have discovered methods of checking their destructive extension. In the rural districts, ignorance has given them all sorts of grotesque designations without the remotest conception of their generic characters, properties, and antidotes. Even where the last have been hit upon by chance, few that use them know what they are contending with, or the reasons of the methods they apply. Nor have hundreds of tillers of the soil, when they grieve over the withered grains of wheat that spoil the sample and diminish the hoped-for return, the least notion of the habits of the little pests which have caused such deficiency. Still less do they suppose that there are men

who can solve these mysteries, and lay the whole facts of such cases before them.

It is the design of the author to unfold some of these secrets which have hitherto been so seldom, if at all, described in popular language. Attention will be principally directed to those blights which are the work of *parasites*, both fungi and insects. It will be proper, therefore, first, to define what is meant by the term *parasite*. It is derived from the Greek word *παράσιτος*, (*parasitos*,) meaning one that lives at the expense of another. From this derivation, it will readily be seen that the term is appropriately taken by naturalists to signify that whatever they so name lives at the expense of some other thing. We should therefore define the parasite of a living organized substance, as another living organized substance produced in and owing its subsequent support to the former. The parasite of a vegetable is another vegetable existing under these circumstances. Parasites of plants are of two kinds, the leafy and the leafless. Those that have leaves, of which the mistletoe is a familiar example, avail themselves of the ascending sap of the plants to which they are attached, elaborating it in their own leaves.

But it is manifest that those which are leafless cannot do so ; they require sap previously converted into proper juice, or descending sap in the plants to which they belong, having no organs of their own capable of effecting this essential process of vitality. Accordingly, they are found growing from the roots of their peculiar vegetables, which they rob of the *cambium*, or sap, that comes down after being elaborated in the leaves. We have a notable instance of such a parasite in the common *cuscuta*, or dodder, which attacks clover, and that sometimes to an alarming degree. Of late years complaints have been made that it has been found in great quantities on the plants of clover raised from foreign seed ; and it would be well to pay attention to the thorough cleansing of it, after importation, from so dangerous an accompaniment. Another common parasite of this species, found also on clover, is the *orobanche*, or strangle-vetch. It is so called from the Greek words ὀροβος, (*orobos*,) a vetch, and ἄγγειν, (*angkein*,) to strangle. It fastens first on the roots, but, unlike the dodder, afterwards sends out its fibres into the soil.

The parasites to which reference will first

be made are principally minute fungi; and as it is impossible to comprehend their action upon the several parts of the wheat plants without some general knowledge of their nature and habits, it will be necessary to occupy a few pages with a description of them. Fungi belong, botanically speaking, to the class of *thallogens*, of which there are three alliances well described in Lindley's Vegetable Kingdom. These alliances are *algæ*, *fungi*, and *lichens*. The first live in water, or very moist places: the last two live in air. Between fungi and lichens the chief distinction is that fungi are never accompanied by any of those curious green *gonidià*,* or separated cellules of the medullary layer of the thallus, which, as well as their spores or seeds, form reproductive matter in lichens. Suppose, then, the question asked, What is a fungus? The answer is, it is a cellular, flowerless plant, deriving its nutriment by means of a *thallas*, to which the name has been given of *mycelium*, or *spawn*: it lives in air, and is propagated by *spores*, which are naked, or by *sporidia*, so called when inclosed in *asci*, or little vesicles. The way in which these spores germinate, generally speaking, is

* Derived from γονή (*gonē*) offspring, or that which begets seed.

by a protrusion of the inner membrane, or an elongation of the outer, thus lengthening out its spawn. This is the usual or *normal* mode: but, as will be hereafter seen, apparently not the only one, for we shall have to describe another method of germination in the case of certain parasitic fungi belonging to our subject. The term *sporule* will also occur, by which we mean the fine contents of the seeds of the fungi. We shall see, in the course of the work, that these fine contents appear to circulate in plants and grow. Fungi may be said to consist of a mass of little cells, or little threads, or of both combined in various ways. They have no fructification except their spores, or sporidia, of which the methods of attachment are singularly curious and beautiful. In their respiratory functions they approach to the peculiarity of animal rather than vegetable life, for they absorb oxygen and exhale carbonic acid gas. Like flesh, they contain a great quantity of nitrogen; and the substance called *fungine*, extracted from them by the chemist, is said to bear a near resemblance to animal matter. They derive their nourishment from the substances on which they grow, and not, as is the case with the lichens and algæ, from the media in which they exist. The juices

impregnated with the peculiar principles of the matter to which any particular fungus is attached, form its appropriate food.

Fungi assume various forms : the simplest is that of a series of articulated threads composed of little cellules placed end to end. We have an example of this form in common mould, as is easily to be seen by submitting it to the microscope. In some of these cases the joints separate, and appear to be capable of reproduction, but, in others, the spores are found on the last joints, and when the cellule which contains them bursts, they are dispersed, and, as soon as they find a suitable place, germination commences. In the next condition, we find fungi assuming a determinate figure, consisting of a mass of chiefly cellular tissue, the interior of which contains the spores adhering to it, and frequently four together. When this dries, the result is a dusty substance, which almost every one has witnessed who has gathered a common puff-ball. With regard to the most complete state, Mr. Berkeley observes, "they consist of two surfaces, one of which is even and imperforate, the other separated into plates or cells, and called the *hymenium*, to whose component cells, which form a structure

resembling the pile of velvet, the spores are attached by means of little processes, and generally in fours, though occasionally the number is either less or greater." Observation of the parts of a mushroom, or any agaric fungus, will readily explain the meaning of this quotation, and convey a true notion of a fungus in its highest condition. As may be easily conceived of such a multitude of cells, some are barren, while the others are fertile. Moreover, formations have been noticed in them which have had attributed to them the performance of the offices of anthers.

Lindley and other eminent botanists are of opinion that fungi might be broken up regularly into orders, founded on a knowledge of these peculiarities of structure.

1. When the *hymenium* (which is a diminutive of ὑμήν, *humēn*, skin or membrane,) is naked, they might be called *hymeno-mycetes*; the term *mycetes* being derived from the Greek word μύκης, (*mukēs*), a fungus. Such are all the agarics, or mushroom-tribes. Their spores are set in fours, on little processes called *sporophores*, or spore-bearers.

2. When the *hymenium* is enclosed in a case, or *peridium*, the appropriate name is *gastero-*

mycetes, from γαστήρ, (*gastēr*,) a stomach. The spores of these are generally also in fours. This order would include puff-balls, and sphærias.

3. The next order is proposed to be named *coniomycetes* from κόνις, (*conis*,) dust. They have a dust-like appearance, as every one knows who has noticed the *uredines* of the corn-plants, to which abundant reference will be made in the course of this work. These have their spores single, or occasionally in sevens.

4. The fourth order would be designated *hymphoycetes*, from ὑφος, (*huphos*,) a web. Such are the fungi attacking vetches, potatoes, etc., called *botrytides*, from βότρυς, (*botrūs*,) a bunch of grapes, the spores hanging naked like berries on the threads. They are also often in sevens in this order.

5. The fifth would be termed *ascomycetes*, from ἀσκός, (*askos*,) a bag, the sporidia, or spore-cases, generally being contained in eights, in vesicles. Of this kind is the *erysiphe*, attacking peach-trees, hops, peas, and beans.

6. The sixth and last should be called *physo-mycetes*, from φύσα, (*phusa*,) a blown bladder, because the spores are surmounted by

a sort of vesicular veil, called by botanists a *sporangium*. The thallus of these fungi is floccose.

Such are the orders into which the fungi are capable of being divided; and when the hard names derived from the Greek language are mastered, they greatly assist in a correct knowledge of these curious plants, without which no accurate investigation into their habits can be effectually made.

The properties of fungi are as remarkable as their forms. Some of them are excellent for food, and are eaten in this country and throughout Europe. The mushroom, the morel, the truffle, are those most generally used for the table in England and in France; but in other parts of the world a large variety form luxuries, greatly valued by the natives of the places where they grow. Some fungi are intoxicating; others are extremely poisonous; but it has been stated, on high authority, that this quality varies exceedingly in different climates, and under the influence of different modes of preparation and cooking. The safest way, nevertheless, is not to venture on any whose wholesomeness has not been well ascertained. Some fungi are beautifully phospho-

rescent in the dark, and give the natural arches of certain mines the appearance of enchanted vaults teeming with indescribable splendour. These luminous fungi chiefly belong to the kind called *rhizo-morpha*, so named because they assume the appearance of masses of roots. They abound in cellars and other places underground. Rhizo-morpha is the matter of fungi developed in an anomalous condition. A curious example was lately placed in the author's hands by professor Henslow. It had grown on the woollen garments of a body, found in a coffin hermetically sealed in a deep vault of Roman construction. Sometimes it has been said that the hair has grown under such circumstances, but in all probability this appearance was merely the similar development of a species of rhizo-morpha; and, in fact, the one alluded to might have easily been so mistaken.

The parts of the globe in which fungi grow ought not to pass unnoticed; for where the range of the thermometer is about the same, and climates are analogous, there is such an identity between the fungi, that it would be almost possible to draw *iso-fungal* lines on a map of the earth.

Many more observations are yet required on

all the natural productions called by the common name of fungi. Some which have been long regarded as fungi are merely blisters of *acari*, or plant-lice ; they are found on leaves of pear-trees, and, till examined carefully, would easily mislead the observer. Others, as for instance those bearing the name of *erineum*, are only diseases of the superficial tissue of the leaves where they make their appearance. It is very essential, therefore, that we should show that diseases of plants attributed to fungi do actually proceed from them.

As may be conceived, speculations upon the fungi have been not a few. They have arisen out of their rapid growth, meteoric character, the increase of species under certain circumstances, the development of parasitic fungi only on particular parts of plants and nowhere else, and many other ascertained facts. But it is best at once to state, that the only *truth-like* solution of their source is the almost universal diffusion of their inconceivably small sporules, which are so numerous and minute, that it is not easy to conceive any place where they may not abound. They are ever at hand, only awaiting suitable conditions for springing up into existence.

It may be said of the great majority of the fungals, that one of such conditions is that they should find a *matrix*, or suitable place for their growth, of some organic matter in a state of decomposition. Herein again such fungi differ from lichens, which are often found attached to living parts of vegetables. Hence fungi have not unappropriately been designated “the scavengers of nature,” as consuming those decomposing substances which would, if left to decay, prove injurious to the health of animals. This is one of those beautiful provisions of a merciful Providence, whereby a natural antidote is called into existence out of the very dangers themselves which arise from natural laws, and tends to beget in the Christian mind that veneration with which the gospel instructs us to regard such evident manifestations of wisdom and goodness. When we look upon those singular appearances called *fairy rings*, in our meadows, we are apt to pass them by with a transient, thoughtless glance, or a momentary wonder at their existence. But science has withdrawn the veil, and teaches us to perceive in them the presence of the *mycelium*, or spawn of the fungi, thus colouring the leaves of our grasses, and writing on the very surfaces of the fields

the excellency of the great Maker of all. This dark hue is attributable to the spawn just mentioned ; and the fungi to which it gives birth both consume putrescent organized matter, and manure the land.

This rule, like most others, seems to have its exceptions. The simplest kind of fungi are not, in the opinion of the highest authorities, confined to substances in a state of decomposition, but attack parts of plants and animals in full health and vigour. Nevertheless, it should be borne in mind that there are many who question whether the seeds of any fungi are, or can be, developed without some incipient alteration in the tissues of the subjects of their attacks. Once started, they increase the malady ; and perhaps they may be started in such incipient stages of disease as to lead to the belief, in numerous observers, that they originate it. Both animals and vegetables may certainly be inoculated by the fungi which are peculiar to them. It is right, however, to say that inoculation produces disease. The silkworm may thus have given to it the disease called muscardine. The fungus, from which this effect results, is called *Botrytis Bassiana*.

In some countries, there is a species of wasp

which is subject to the growth of a fungus, and is not unfrequently seen upon the wing with it adhering to its body. One

Sphaeria Robertsia.

of the most curious instances of a living animal thus infested was discovered in New Zealand. There is in those islands a caterpillar of a large moth, which inhales the sporules of a fungus called *Sphaeria Robertsia*. When this happens the caterpillar buries itself in the ground, and the whole interior of the body is replaced by a black mass of spores. One of these generally seems privileged to grow, and rises from the nape of the neck of the caterpillar into a tapering fungus, as represented in the annexed figures. If by any chance this stem is broken off, another rises to succeed it; but, generally



speaking, one only emerges at a time. Such an instance of an animal destroyed and replaced by a fungus, affords a striking proof that a retrograde step is sometimes to be found in the animal kingdom. The usual tendency in the insect creation is to an advance. Each change leads to a higher degree : the egg becomes the caterpillär, the caterpillar becomes a chrysalis, and the chrysalis is at length transformed into some beautiful winged fly, often seen glittering in vivid colours under the beams of the noon-day sun. The knowledge of such a transformation leads to reflections deduced from things present, on the future destiny of man. These thoughts are strikingly embodied in the following lines :

“ Oh, start not ! on thy closing eyes
Another day shall still unfold ;
A sun of milder radiance rise,
A happier age of joys untold.
Shall the poor worm that shocks the sight,
The humblest form in Nature's train,
Thus rise in new-born lustre bright,
And yet the emblem teach in vain ? ”

These beautiful progressions seem to give the Christian a natural shadow of a hoped for existence of a nobler kind. True, the shadow is feeble, but yet it manifests that the promise of

a life to come, is but a grander realization of that which things under our constant observation proclaim to be in unison with the proceedings of the Author of all existence in certain of the works of his hand. We see that such a declaration in his revealed word is in consistency with himself in his lower operations. Unimportant as are the transformations before us compared with our resurrection unto life, still it is most interesting to perceive that a faint type of it exists in the world. No longer, then, can the sceptic stand upon the false position, that, from all that is presented to our notice, it is "incredible that God should raise the dead." But hitherto, while such facts have been adduced as auxiliaries to the believer's faith, no notice has been taken of the circumstances which, upon the same principles, may be brought forward as confirming, in their degree, the warnings of the gospel addressed to unbelievers. The reason is, that such a retrograde step as the one before us had escaped observation. Let us mark in it the fact that this caterpillar, under the agency of this enemy to its health, passes diseased into the ground and dies, while soon there comes forth from its decaying body the inferior replacement of a

nauseous fungus. If, then, we are to learn a lesson from the former examples of ascent in the scale of existence, why not from this of unquestionable descent? Can we see no analogy here, comparing things small with great, and things natural with things revealed, of the going down of the ungodly into a condition of degradation, and of their coming forth into a state of life far below that in which they now are? If the inference holds good in one case, it does so in the other, and forcibly implies the possibility of those who are to the last under an uncured and unpardoned taint of sin, rising to shame and contempt.

. Some kinds of fungi may be almost called terrestrial. Even in this country there is one (*cyphella*) which grows on little gravel-stones; and certain exotic fungi are found on tupha-like earth.

We have spoken of the *mycelium*, or spawn, of fungi, and the question may be naturally asked, what is it? It is merely the development of the spores of fungi, or the further increase of mycelium already produced. It varies much in appearance in the different tribes, being *mucedinous*, or *gelatinous*, or *vesicular*, as the case may be.

The cereal fungi have their mycelium present in healthy plants, and under favourable circumstances they are developed. These are the kinds to which attention will be principally directed in the pages of this little book, and they are extremely minute, requiring high powers of the microscope, as well as practised observation, to obtain accurate knowledge of their forms and habits. They generally appear in *sori*, or patches, consisting of multitudes of spores, that form frequently so many cases inclosing the reproductive sporules, which, as has been stated, float in the atmosphere around us until they light on some place adapted to their growth. Their extreme minuteness allows of their being introduced, by methods hereafter to be explained, into the substance of the tissues of plants, or beneath the epidermis. As they grow on the leaves, or straw, of corn-plants, they raise the epidermis into curious puffy blisters, which they subsequently rupture, in the same way as the large toad-stools have been known to lift up the flag-stones of a paved street in a town in the process of their development. These patches are of different colours, but most commonly either deep yellow, brown, or black. The several parts of the wheat-plant are attacked

by these parasitic pests, which are quite distinct from each other, having nothing in common, except that they germinate within the tissues. When the habits of these fungi have been fully described, the reader will be prepared for any concluding observations space may allow at the end of this work. At present, sufficient has been said to open the way to a clear comprehension of the statements about to be made.

With regard to the insects which will come under review, no preliminary description is required, as the story of their encroachments includes that of their natural peculiarities, and we have only to deal with such as produce blight in the wheat, and may be called true parasites, produced in, and living upon, certain portions of the plant.

The order in which the fungi will be treated is the following :-

1. Those attacking the *straw*.
2. Those attacking the *leaves* and *chaff*.
3. Those attacking the *flower*.
4. Those attacking the *grain*.

After these fungi have been traced in their growth and effects, a description will be given of certain extraordinary animalcule called *Vibriones Tritici*, or eels of the wheat, which ren-

der the grain abortive. Then will be introduced a review of that remarkable change in the grain itself which has been designated *Ergot*, from the peculiar form it assumes, and which is a subject deserving far more attention than hitherto has been given to it. Parasitic flies which devastate the wheat-crops will form the next subjects of inquiry, to which will be added a series of observations, on matters connected with the principal topics embodied in these pages, made with a view to excite more inquiry into these and kindred subjects of deep interest both to the philosopher and the practical agriculturist.

CHAPTER II.

Fungus attacking the straw—*Dipazea* on the joints—*Puccinia Graminis* or corn-mildew—Explanation of the term—Habits of growth—Microscopical appearances—Shape of the spores—Their situation with regard to the stomata of the stem—Functions of the stomata—Method of seeing them well with the microscope—Sporules of *puccinia* enter the plant by them—Pamphlet of sir Joseph Banks—Drawings of Mr. Bauer—Old Testament mention of mildew—Grasses and reeds subject to it—It appears in the autumn—Fries, on the universal diffusion of sporules—Farmers' clubs—Value to them of the microscope—Method of examining the *puccinia*—Another fungus frequently mistaken for it—Remedies against *puccinia*—Parasites removed by cleanliness, both from plants and animals.

OUR inquiry into the habits of the parasitic fungi, found upon the wheat-plant, will commence with one of its most common pests attacking the straw. And here it may be mentioned, that the joints of the straw are not unfrequently affected by a small and almost unobserved fungus called *dipazea*, upon which it is unnecessary to dwell, for it is not considered as making its appearance on stems in a

healthy condition. It is a very minute species of *sphaeria*, and may frequently be noticed if the joints are carefully examined. But in the case of the fungus now to be described, the fields, especially of late varieties in certain localities, may be often perceived to be quite blackened by its encroachments, while the grain, as well as the straw, becomes exceedingly deteriorated. On gathering a stem, it will be found completely disfigured by numerous dark blotches of the *sori*, or patches, often running its entire length. The common name of this disease is mildew, and it has been designated by botanists *puccinia graminis*, a term supposed to be derived from the Greek word *πίκα*, (*puka*,) signifying closely or thickly, and to have reference to the crowded condition in which the little fungi are packed in the several patches in which they grow. When the disease first shows itself, the stem exhibits a number of dark-coloured spots beneath the epidermis, some of which have an orange-coloured tinge, others a deep brown. In a short time, the outer cuticle splits, and dark musty clusters of spores appear in the openings. On examining these with the microscope, they manifest distinct and curious forms. They are seen to be

dense masses of pear-shaped fungi with a stalk, into which each one gradually tapers.

The threads of *mycelium*, or spawn, are not visible, but they interweave themselves amongst the tissue of the straw, and it is from them that the spores emerge, and break through the epidermis. A beautiful figure of it may be seen in Corda's celebrated drawings of fungi; but it requires great skill and a very powerful microscope to see it well.



Piece of straw with mildew, as viewed under the microscope magnified 125 diameters.

The usual magnified appearance of a piece of mildewed straw is represented in the drawing, viewed as an opaque object by a good achromatic glass. The pear-shaped bodies thus clustered together are the spores of the *puccinia*. If a small quantity be scraped off with the point of a knife, and further mag-

nified, they will be still more distinctly seen. They are well represented in the figures we have given, the round spore being one of *uredo*, or rust, mixed with those of *puccinia*.

Each of the two compartments into which these spores are divided is filled with *sporules*. The spores themselves generally make their appearance immediately beneath the *stomata*,



Spores of *puccinia* separated from the straw and magnified
240 diameters.

or pores, with which the stem abounds. These *stomata*, it is well known, are the organs by which plants exhale and inhale. Under the influence of light, and in dry weather, the *stomata* are in active exhalation; but in wet and gloomy seasons these functions are reversed, and they inhale powerfully. It is then that, in all probability, the *sporules* are imbibed with the moisture, and find a suitable

place for vegetating in the subjacent vegetable tissue, when favourable atmospheric circumstances, neatly designated by a foreign philosopher, "*cosmica momenta*," call them forth.

As some of the readers of these remarks may never have seen these beautiful organs called *stomata* in the vegetable structure, whose functions are so indispensable to the life of the plant, it may be proper here to mention the simplest method of obtaining a knowledge of their character by actual observation. They are found in the leaves of all vegetables, and in the stems of the gramineous tribes, including every sort of British corn plant. They also occur in their leaves. They are small spaces which lie between the sides of the cells in the cellular tissue, and open into intercellular cavities in that part of the tissue lying beneath them. *Stomata*, the plural of *στομα*, (*stoma*,) a mouth, is an appropriate name. When seen with a good microscope, their appearance is most interesting. They form apertures for the purposes mentioned, and these apertures are closed or opened by little elastic vesicles, whereby their action is beautifully regulated. The naked eye can never detect them, but under a good microscope no

object whatever is more completely defined. Those persons who have not seen them, cannot do better than to cut with a pair of scissors a small bit from the leaf of the plant called St. John's wort. Place this little fragment on a slip of glass, with the under side, in which the stomata abound, uppermost. Take a good half-inch achromatic object-glass, and put on the speculum. Throw the light on with the mirror attached to the microscope, and view the leaf with an appropriate eye-piece. To the astonishment of every one witnessing this sight for the first time, the whole surface will appear closely studded with the stomata. Some will be found open, others shut; but the whole will be seen with the utmost distinctness. Ever after, the use of the term will present no difficulty; and if other leaves and stems be submitted to a similar inspection, whatever is said relative to these minute organs will become intelligible. A practised microscopist will show them admirably by scraping off a slight morsel of the cuticle of a leaf, and putting it on a piece of glass with a slip of very thin glass over it. The power then used should be one-eighth of an inch. The location of the spores of mildew in wheat

straw, as stated, naturally induces the observer to conclude that the sporules enter by the stomata. In other fungi, to be noticed hereafter, it is to be inferred that the process of entering the plant is different. We now speak only of *puccinia*.

In the year 1804, the complaints of the mischief done to the wheat were of so serious a nature, that sir Joseph Banks caused some stalks of the plants affected by what was then merely called blight, to be carefully examined by the microscope. The person employed was the celebrated Mr. Bauer, who made drawings of the fungi with his usual skill. A large volume of these productions of the pencil of that eminent observer is preserved in the British Museum. Mr. Bauer delineated the *puccinia*, which had vegetated on the straw and prevailed to such an alarming degree, with extreme accuracy. He did not, however, detect the mycelium, as Corda has done since. In 1805, a pamphlet was published on the subject, asking for observations from intelligent agriculturists on the origin and progress of the disease. This publication embodied a principle which is now more regarded than it was in those times. It was commended to the notice of farmers as justly

deserving their attention, and the principle itself was, that the exercise of their intellectual faculties upon the objects with which they are conversant would, in time, convey to them a practical reward. An extract from the pamphlet, taken from Loudon's *Encyclopædia of Plants*, will show the design of the writer; but it was at that period productive of no great effect. "Botanists," he says, "have long known that the blight in corn is occasioned by the growth of a minute parasitic fungus, or mushroom, on the leaves, stems, and glumes of the living plant." In this observation sufficient distinction is not made between the different forms of these fungi. The fungus alluded to here is only the *puccinia*, which is by no means the sole fungal blight to which the corn-grower's attention ought to be urgently called, as will abundantly appear in the course of this treatise. Mr. Bauer's drawings in the British Museum contain nearly all the fungi referred to, elaborately and beautifully figured. The pamphlet continues, "Felice Fontana published, in the year 1567, an elaborate account of this mischievous weed, with microscopic figures which give a tolerable idea of its form; more modern botanists have given figures both

of corn and grass affected by it, but have not used high magnifying powers in their researches. Agriculturists do not appear to have paid, on this head, sufficient attention to the discoveries of their fellow-labourers in the field of nature ; for though scarcely any English writer of note on the subject of rural economy has failed to state his opinion of the origin of this evil, no one of them has yet attributed it to the real cause, unless Mr. Kirby's excellent papers on the diseases of corn, published in the Transactions of the Linnæan Society, are considered as agricultural essays. On this account, it has been deemed expedient to offer to the consideration of farmers, engravings of this destructive plant, made from the drawings of the accurate and ingenious Mr. Bauer, botanical painter to His Majesty, Geo. III., accompanied with his explanation, from which it is presumed an attentive reader will be able to form a correct idea of the facts intended to be represented, and a just opinion whether or not they are, as is presumed to be the case, correct and satisfactory. In order, however, to render Mr. Bauer's explanation more easy to be understood, it is necessary to premise that the striped appearance of the surface of a straw,

which may be seen with a common magnifying glass, is caused by alternate longitudinal partitions of the bark, the one imperforate and the other furnished with one or two rows of pores or mouths, shut in dry, open in wet weather, and each calculated to imbibe fluid whenever the straw is damp. Pores, or mouths, similar to these, are placed by nature on the surface of leaves, branches, and stems of all perfect plants ; a provision, indeed, intended no doubt to compensate in some measure the want of locomotion in vegetables. A plant cannot, when thirsty, go to the brook and drink ; but it can open innumerable orifices for the reception of every degree of moisture which either falls in the shape of rain and of dew, or is separated from the mass of fluid always held in solution in the atmosphere. It seldom happens in the driest season that the night does not afford some refreshment of this kind, to restore the moisture that has been exhausted by the heat of the preceding day." The writer then proceeds to say that it is by these pores, or *stomata*, as we have called them, the seeds of the fungus gain admission ; and with respect to the one now before us he is right, according to

our supposition. So exceedingly small is each individual spore of the mildew, that sir Joseph Banks was persuaded that any single *stoma* on the stem would produce from twenty to forty germinating in the hollow beneath it. In such positions, where they are invariably found, they intercept the sap originally destined for the nourishment of the grain, while they prey also on the tissues; so that the grain, by these means, failing to receive its proper nutriment, becomes shrivelled and defective, in proportion to the number of the fungi which thus rob it of its sustenance. The corn sample is accordingly bad to the eye and deficient in flour, yielding, at the same time, a quantity of superabundant and inferior bran.

In all cases where such a little pest as this becomes multiplied to a great extent, it gives rise to fearful consequences. We find it frequently mentioned in the Old Testament, that the "mildew" was one of the Divine judgments for the sins of the people, who, even under that infliction, still failed to return to the Lord their God. Solomon, in his prayer for Israel's prosperity and safety, intreated the Lord that when under the pressure

of this particular affliction they might be heard and forgiven. To Omnipotence, number has no limits, and the smallest thing God has made can be so augmented in quantity as to accomplish vast designs.

All the tribes of *gramineæ* seem more or less subject to puccinia, and it is frequently found on the leaves of different kinds of reed, presenting unmagnified the precise appearance represented in the sketch, and which is indeed much the same as on the straw of wheat. The shape of the spores are, however, somewhat different. It does not generally break out into patches till the autumn has considerably advanced; hence rye, which ripens earlier than the other corn-plants, is seldom much attacked by this parasite. It is common to almost all countries; and when the eye of the observer has once become accustomed to it, the

Mildew on a Leaf of
common Reed.



Puccinia
Arundinacea.

true *puccinia* is instantly detected, as well as the dark-coloured spots under the cuticle, which precede its rupture by the spores. Moist seasons, damp situations, over-manured lands, and lateness in the crops, are peculiarly favourable to mildew, which almost always appears in a chance plant of wheat that may have vegetated on a manure-heap. Some say this is invariably the case, but it is far too loose an assertion. The rapidity with which it sometimes spreads is astonishing ; only let the circumstances be favourable, and millions upon millions of sporules seem ready to enter the stomata, and germinate beneath them. The atmosphere is charged to an inconceivable extent with such invisible organs of reproduction. Fries declares the sporules to be so infinite that they rise like thin smoke into the air by evaporation, and are dispersed in innumerable ways ; as for instance, by the attraction of the sun, by insects, by wind, by elasticity, or by adhesion. He asserts that in one individual he calculated on good grounds, that there were at least ten millions, if not more. Thus a stoma can scarcely ever perform the function of inhalation without taking in more or less of these sporules ; and it is a happy circumstance

that they refuse to grow except in certain places, and under peculiar conditions ; for if their vegetation were general, the produce of the earth would be almost entirely consumed by them. There is no subject on which grosser mistakes are made, even by writers well-informed on other topics, connected with these fungi. The cause is, that attention has not been properly paid to it, from its apparently recondite nature. But it is hopeless to expect a systematic adoption of remedies while the veil of ignorance invests the cause of disease. It was curious to see, in the speculations on the potato disease of 1845, how vague the ideas of their authors were respecting the fungi. But the great improvements in modern microscopes will be attended, it is hoped, with the increase of much important knowledge. Under the able management of Mr. Berkeley and others, these instruments have already done wonders ; and what a number of otherwise listless winter hours might an agriculturist pass, with the aid of a good Argand lamp, in acquainting himself with these little pests which constantly attend his labours. Farmers' clubs have multiplied throughout our rural districts, and every one ought to possess a microscope. There would

be always found one or more members able to exhibit this instrument, and others would soon learn its use. Ministers might sometimes attend at such meetings, and would find revealing the secrets of nature no unworthy or ineffectual step towards awakening attention to the more weighty objects of their sacred calling. The author has more than once shown these corn diseases to the members of a farmers' club, who viewed them with extreme interest. Nothing can be more simple. To show the *puccinia graminis*, or mildew of the wheat, the exhibitor should first strip off lengthwise a little bit of the affected straw, and let it be viewed as an opaque object. The thick clustering of the spores, as delineated in the first drawing of this chapter, might be easily pointed out, as well as the way in which they rupture the cuticle: an half-inch achromatic object-glass, with a low eye-piece, will suffice for this; with a higher power, and bits of cuticle and straw, cut so thin that the light may easily be shown through them from the mirror, the stomata would be seen, and the vegetation of the spores on the mycelium in the cavities beneath them. Lastly, a small piece of one of the dark patches might be taken off with the point of a pin or

of a small penknife, and laid on a strip of glass. Moisten this with a little drop of water, and cover it with a small fragment of the very thin glass sold by opticians for such purposes. Place it on the stage of the microscope, show the light through it, and look at it with a quarter or eighth of an inch achromatic. The structure of the spores, the division of the chambers, the stalks, and every part of them will become distinctly seen, just as they are depicted in the second drawing. The observers would become by these means perfectly acquainted with this fungus.

It is a common error to say that wheat which often appears covered with a black sooty fungus, dusting the ears all over, and accompanied with signs of general decay, is *mildewed*. Although this dust is a fungus, it must not be confounded with puccinia. Its botanical name is the *cladosporium herbarum*, so called from the Greek word κλαδος, (*klados*,) a branch, because the spores are terminal on small and pointed branches. This fungus is undoubtedly always accidental to some previous disease, and is only superficially attached to a decomposing plant, while the ear appears as represented in the next page. There is no symptom of

the sporules having, as in the cases of *puccinia*, entered at all into the tissues of the plant, and having caused any deterioration of the vegetable system. Even the naked eye may detect a difference in the general effect, but the microscope shows an entire and perfect distinction. There is not the slightest resemblance between them. The confusion of ideas consequent on such ignorance may be readily conceived, while palliatives have actually been given to the world in various shapes fostering the error. Where the soil is stiff, or boggy, and when winds have injured the crop, or the rain laid it on the ground, it becomes unhealthy: then the *cladosporium* seizes it; but the cause, and therefore the remedy, is not the same as in the case of true mildew. We see from

Ear of Wheat attacked by the *Cladosporium* Herbarum.

these facts, that truth only results from careful research and accurate examination. There is not a thing, however minute, in the material scene around us, which may not afford some hint for our benefit :

Nothing so slight
Which in nature sends not forth some light.

QUARLES.

The next question that suggests itself to us is—What remedies may be successfully applied to check the devastating growth of puccinia, or corn mildew? Although its botanical character is now so well known, the remedies hitherto suggested have been principally conjectural. Mr. Knight, who was a most careful and experienced observer, expressed his persuasion that when fogs come on after a very dry time, the wheat-plant is more than ordinarily subject to this blight. This opinion is in unison with the supposition in the preceding pages, relative to the action of the *stomata* under such circumstances. Hence the obvious method of guarding against mildew in places particularly subject to its influences, is to endeavour to procure the earliest varieties, which may arrive at maturity before the

autumnal fogs extensively prevail. More observations are also wanted as to the effects of soils on the growth of this fungus, and especially whether heavy soils are really more favourable to it than light ones. There is as yet little more than surmise on these points, which is always unsatisfactory. Nor is it well decided whether spring wheats are less liable to it than winter wheats, though an opinion that such is the case widely prevails. Agricultural societies should make all these things matter of accurate special inquiry, which can only be known from practical men.

The certainty that all the gramineous tribes are liable to mildew, renders it very doubtful whether the extermination of this evil can ever be expected; but, unquestionably, much may be done towards checking its injurious diffusion to any alarming extent. The proper method is, to consider what remedies may be safely recommended, and to try them carefully. The following are undoubtedly worthy of attention :

1. An endeavour as inexpensively as possible to change the texture of soils by amendment by mixture, where mildew has long obstinately prevailed. The farmer should learn that the

mechanical state of his land is just as important as the chemical. Glass, which refuses to part with its alkalis when in a solid state, if brought into contact with water, parts with them easily when moistened, after being finely pounded in a mortar. Any person may convince himself of this fact, by laying a lump of wetted glass on turmeric paper. No result follows. Now, reduce the same piece of glass to fine powder, and wet it ; the turmeric paper turns red, indicating that an alkali has been set free. Hence the fine mechanical division of the soil effected by judicious mixture of more friable materials, may produce great results in giving out organic compounds whose tendency is to strengthen it against the attacks of disease. This is only one instance out of thousands, to show the importance of science to a class of men long entirely neglectful of its advantages, but now becoming more aware of them.

2. A careful notice of many places where mildew has prevailed, will at once satisfy the observer that they have been so situated as to be subject to the evils of too much shade, or want of free circulation of air. Letting in more air and light in these localities, by obvious

means, would be, in such cases, the best mode of proceeding.

3. There is no doubt that over luxuriance in early growth is favourable to the mildew. The intelligent farmer will know best how to check this, whether by feeding it down with sheep for a few hours in the day-time, or other methods. This must be a matter of experience, keeping only the design in view.

4. The desirableness of growing early varieties in places subject to mildew. The reasons have already been considered.

5. Another plan worthy of being adverted to, is the avoidance of manuring immediately before setting the seed.

6. Attention should also be given to hoeing the wheat crops in the early stages of growth, and taking great care to free them from all weeds. Mildew will seldom prevail to any extent where this precaution is taken; but wherever there are many weeds on the land, the straw will be generally found more or less affected by it. The author can say from experience, that he has seldom, if ever, failed to meet with it in unclean lands.

Wherever the farming is of the best kind, where these precautions are taken, and where

drainage is good, this fungus will not be found in any alarming degree. Just as the clean skin of animals is a defence against nauseous living parasites, so, by an analogous method, the soil will be rendered free from the destructive fungi under our present notice. Improved domestic habits in our peasantry are well known as tending to check the spread of epidemic diseases ; and, in the same way, a better system of cultivation will avert diseases from our corn-fields, while there is given thereby increased opportunity for the employment of the poor. Mildew was once more prevalent than it is at present ; and doubtless its diminution is in a great measure to be ascribed to a better husbandry.

CHAPTER III.

Fungi found on the leaves and chaff-scales of wheat—*Uredo*—Derivation of the term—Two kinds attacking wheat in all stages of growth, and called red-rust, red-robin, etc.—Uredines belong to Order iii. (Coniomycetes)—Microscopic examination of red-robin—Disappears under the influence of sunshine—Curious botanical question as to its relation to *puccinia*—Value of such inquiries to practical men—Rust more dreaded on the continent than *puccinia*—Not so in this country; but still injurious in late stages of the growth of the plant—Remarks on three other fungi—The last very destructive, but not yet found in Great Britain—*Uredo segetum*; its common names, smut, etc.—Attacks the flower and its organs—Singular prejudice in its favour—Investigation of Mr. Bauer—Microscopic appearance of spores—These spores found not to be diseased cells, but true fungi—Effect of substances, by which they are nourished, on the forms of fungoid matters—Mode of action of *uredo segetum*—Excessive smallness of the sporules—Their probable mode of entering the plant—Difficulties of this point, and remedies, reserved for chapter iv.

IN pursuance of the plan announced in the first chapter, attention will be next directed to the fungi found on the leaves and chaff-scales of the wheat-plant. They are different in appearance from *puccinia*, but one of them sometimes affords reason to suspect that it is in nearer alliance with it, than has hitherto

been imagined by botanists who have observed the two separately. These fungi are called *uredines*, the plural of *uredo*, which is a term derived from the Latin word *uro*, to burn, because the discoloration of the parts of plants affected by them produces a burnt appearance. The uredines are chiefly found on the young or old leaves of corn-plants, and occasionally on the stems ; but, in the last instance, it has been surmised that the indications similar to *uredo* are only immature forms of *puccinia*. We shall soon have to advert to this point. There is no stage of growth in which the wheat-plant is free from the attacks of a *uredo*. Early in the spring it is found on the young blades ; and this year (1846) it was in such quantities in some districts, that the fields looked quite yellow with it, and at one time it produced much alarm. Later in the season, it often abounds in the glumes and paleæ of the ear, even after the grain is formed. These yellow or orange uredines are of two kinds. One of them, from the oblong form of its spores, is called *uredo linearis*, the other *uredo rubigo*, whose spores are nearly spherical. *Uredo rubigo* means red rust, and no name could possibly convey a truer idea of

its appearance. Both these uredines are closely allied to the rust on the leaves of rose-trees, called *uredo rosæ*. Their colour varies from orange to a brownish hue, and they cause the parts attacked to look as if they were dusted with rustiness of these colours. They belong to the order *coniomycetes*, or dusty fungus. It is a rare thing to find any wheat-field altogether free from them at any season of the year. When the chaff-scales are at-

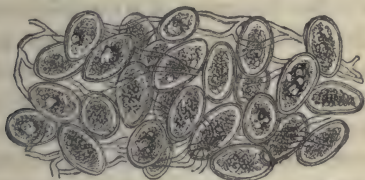


Chaff-scale affected by red-robin,
highly magnified.

tacked, the spots look exactly as they are represented in the one here drawn, and the matter forming them exudes like a red gum from the inner surface. Hence red-gum is a name sometimes given to it; but it is most frequently known as red-robin, red-rust, or red-rag.

The chaff-scale delineated here, gives no further indication of the character of this

fungus, than the manner in which it comes out and spots the parts of the plant where it vegetates. To see the form of the spores requires a very high power of the microscope, by which it may first be viewed as an opaque object, and then a small bit should be scraped off and treated in the way described in the case of *puccinia graminis*. The spores will appear of the forms accurately exhibited in a drawing by Mr. Leonard, from a specimen given him by the author to examine and figure. The fine threads of the *mycelium*, or spawn, are extremely well shown. Thus magnified, the organization of these fungi is perceived to be beautifully delicate, and the red gummy powder is found to be composed of innumerable spores growing from the spawn-threads, as here represented.



Spores of uredo, magnified 240 diameters, showing the *mycelium*.

The botanist therefore becomes completely

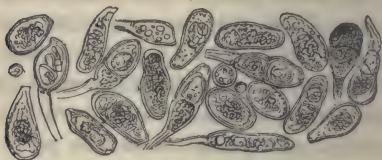
acquainted with the distinctive character of the uredo by the aid of the microscope, while the vegetable physiologist is enabled to form an opinion on its peculiar habits and modes of growth. The real habits of this common disease of the wheat-plant, are no longer veiled by inaccurate observations, or popular imaginations. The mystery is cleared up, and the cultivator who has often witnessed the discoloration of his crops by this fungus, without any real knowledge of its nature, may now become thoroughly acquainted with the object of his frequent surprise and annoyance.

Very often, as happened in the spring of 1843, and in that of the present year, 1846, the corn-fields have seemed quite to droop under the influence of this parasite. The aspect on such occasions is so sickly as to create serious alarm. But the arrival of a few bright warm days soon dissipates the evil. The genial beams of the sun seem completely to vanquish it, so that it disappears in an astonishing manner, and a healthy greenness speedily succeeds to the sear and yellow tints that have disheartened the farmer. The fact is, that when the sun dries up the superfluous moisture, the fungus cannot spread, and health returns. It

reminds us of the moral maladies which disappear before the light of truth.

We will now proceed to notice the opinion of certain eminent botanists, that *uredo rubigo* and *uredo linearis* are only imperfect forms of minute fungi, which, in their perfect state, are known by other names. For example, it is said the uredo of the rose passes into a condition called *aregma*. So it is considered by professor Henslow, an eminent and most judicious observer, that uredo in the corn passes to *puccinia*. He published an able paper in the "Agricultural Journal" for 1841, on what he designated "the Specific Identity of the Fungi producing Rust and Mildew;" and his arguments are ingenious and well worthy of perusal. The point is considered by him as fairly established by observation of certain intermediate forms, confirming their connexion and proving the identity of their origin. With regard to these appearances, the author desires to state that, in the autumn of 1845, he found in a wheat-field many specimens of yellow-looking blotches on the straw, which seemed to confirm the professor's opinion. Examination by the aid of his own microscope, revealed forms similar to those drawn and described in

the paper recently alluded to. He placed a specimen in the hands of Mr. Leonard, requesting him to observe and delineate what he saw. The result was the group here shown, in which the several stages suspected as existing may be seen. It looks certainly like a



Various forms of the spores of the wheat mildew of 1845,
magnified 240 diameters.

case of transition. All, however, that the author can as yet venture to assert is, that some puccinia have clearly the appearance of uredo before the *septum*, or division of the spores into chambers, is fully developed. In a splendid figure by Corda, these various forms are given with great effect as they burst the epidermis; and the drawing of that incomparable delineator of fungi confirms the opinion that the last observation is the one that is safe and accurate. Questions of this kind will be viewed at first sight as purely botanical, though they certainly tend ultimately to the

combination of science and practice. For if certain parasitic fungi, hitherto supposed to belong to genera entirely distinct, can be shown to be specifically identical, there will be a reasonable expectation that any remedy or palliative discovered for the disease in one stage, will preclude the necessity of seeking a different corrective in another. Rust and mildew may then be checked by a common treatment. More observations are, however, still required on this curious subject. A remark from professor Henslow is worthy of notice. He says, that the rust seems to be more common and more dreaded on the continent than the mildew, whilst with us the mildew is considered a far greater pest than the rust. "Is it," he adds, "that our climate is better suited to the more complete development of the spores of these parasitic fungi, and that our continental neighbours are more rarely favoured with the opportunity of seeing them in their most perfect form?"

The rust is perhaps the least alarming in England of all the parasites attacking the wheat. Unquestionably it passes off in the way described more readily than any other; but when that beneficial influence of sunshine

is not effectually exerted, a deterioration of the crop takes place. When it is found in later stages of growth, and on the glumes and paleæ of the chaff, it is more injurious than when it merely appears in the earlier periods of growth.

This is the proper place for a few remarks on certain other fungi, not so common as the red-rust, or red-robin, which are occasionally found on the leaves of the wheat plant. One of these is the *erysiphe graminis*, almost universal on it in 1845, but which did not seem to do much harm, and upon which therefore there is no need to enlarge. On the continent, there are two species of moulds which are extremely curious, and one of them is fearfully destructive. The former called *chionyphe*, from its being developed during snow, was discovered in Iceland, by Thieneman. Two other species have since been seen in the neighbourhood of Dresden, where they were abundant. This singular mould is found on the snow, when it just melts before the sun, without any general thaw. It consists of spreading shining fleecy patches, and the reproductive portion of it is sometimes red and sometimes green. As soon as the snow melts, it appears on the young herb in a stratum resembling a cobweb of great delicacy, which is

not of long duration. It is most likely due to the existence of some animal matter in the soil, and is extremely remarkable; though by reason of its vanishing so quickly, not attended with disastrous results.

Not so the other, called by Unger *Lanosa Nivalis*, with reference also to its coming in time of snow. Unlike the last, this fungus is developed beneath the snow, and is excessively injurious both to grass and corn. During the spring of 1846, a description of it was published in the "Gardener's Chronicle." It appears in white patches, a foot, or even more, in diameter, tinging the snow with a red hue, arising from the spores of the fungus which are of this colour. When a spore is greatly magnified the coloured contents are very perceptible. A completely withered plot is left behind, wherever this fungus has run its course. When snows have come on without previous frosts, it has been known to destroy whole crops, particularly of barley and rye. In places where it prevails, the farmers plough up the frozen surface, so complete is the mischief effected on the young plants. Happily for us, it has not yet reached Great Britain; but that it will not, no one can predict, for all fungal diseases are

very alarming, and may appear when least expected, especially in a climate where the seasons vary as they do in ours.

The next parasitic fungus is the one which so materially affects the flower of the wheat-plant, and which has in many places prevailed most extensively this summer, 1846. It is much more minute than those previously described. The name given to it by botanists, is *uredo segetum*. Farmers call it by various appellatives, as "smut, dust-brand, bunt-ear, chimney-sweeper;" the last designation evidently arising from its looking exactly like a coating of soot adhering by some gummy substance to the young ear.

An ear of Wheat spoiled by the *uredo segetum*.

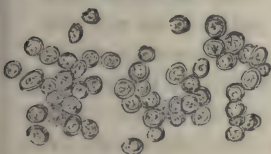


An ear of Barley spoiled by the *uredo segetum*.

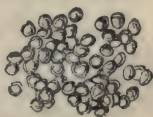


It reduces the ears both of wheat and barley to the condition figured in the drawings, and has the same effect upon oats. The black masses of sooty powder are the spores of the fungus which are here delineated, magnified 375 diameters.

Spores of *uredo segetum* in wheat,
magnified 375 diameters.



Spores of *uredo segetum* in barley
magnified 375 diameters.



The specimens from which these drawings are made, were gathered by the author in the summer of 1845. The ears were, in both cases, completely ruined. Some farmers say they like to see a little of it, because it is always accompanied by a good crop. Certainly, as professor Henslow well observes, the "little" can only be, with any propriety, on the principle of the less the better. Undoubtedly every ear attacked is destroyed, as is evident from the first instant it emerges from its hose, or sheath. The extreme smallness of the spores of this fungus may be inferred from the drawings,

but still further from M. Bauer's investigations. He says the one hundred and sixty-thousandth part of a square inch contained forty-nine of them. Hence he calculates that not less than seven millions eight hundred and forty thousand would be required to cover a square inch English measure. It has, indeed, been a question with some persons, whether these appearances are not due to a mass of diseased cells, and that they are not fungi at all. But the answer to this is, that diseased cells would not germinate, which these uredines unquestionably do. There is no apparent difference, generally speaking, between the spores of this uredo in wheat and barley; but there is certainly a degree of dissimilarity in those delineated in the figures before us. This is probably due not to the difference in the fungi themselves, but to the matrix where they grow; and there is great reason to believe that the produce of fungoid matter does vary in this manner, and even to a greater extent, with the peculiarities of the matrices by which they are nourished. If the spores of this uredo are so small, what must the sporules be as to dimensions? The highest imaginable power of a microscope could only be expected to exhibit

them as a vapory cloud. The next question is, how the fungus acts upon the part of the plant which it principally affects.

When the plant is attacked by this fungus, the first injuries are found upon the interior portions of the flower, which render it completely abortive. In a short time afterwards, the *pedicels*, or little stalks, to which the florets are attached, swell and look hard and fleshy. At length the whole is consumed; and the ear, particularly in the case of wheat, becomes dismantled of all its reproductive organs, and the remainder is powdered over with the before-mentioned black, dusty smut, which has a most disagreeable appearance. In all specimens the author has ever seen, the fungus has been visible only in the ear. M. Bauer, however, states that it has been found in some other portions of the plant. These instances are certainly very rare, and have been noticed by scarcely any observers. In some seasons, immense quantities of it may be seen, during summer, in the corn-fields, long before the rest of the grain reaches maturity. All these ears are, as we have said, destroyed by it, and therefore the amount of crop greatly diminished. But as its spores are scattered to the winds for

weeks before the reaping begins, the farmer scarcely sees it during the harvest, and consequently thinks but little about it. This is probably the true solution of the prejudice in its favour.

There is every reason to believe that the fungus enters the plant by means of its sporules being so small that they find access with the ascending sap, by the spongioles of the roots. With this sap the sporules circulate, and are developed as has been described. Some difficulty attends this view; but it will be partly cleared up in the next chapter. There, also, allusion will be made to the remedies which are common to this and the parasite to be next described.

CHAPTER IV.

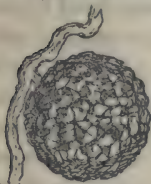
Uredo foetida destroying the grain of wheat—Its disgusting odour—Popular names of this fungus—The most common one, Bunt—Appearance of bunted grains—Microscopic examination of the spores of bunt—The mycelium—Pedicels by which the spores are attached to it—Green colour of bunted grain before ripening—M. Bauer's observations—Effect of the presence of mycelium on the green colouring matter of leaves—Question whether the fine contents of the spores of bunt circulate in the wheat plant, and grow—Experiments tending to show that they do grow—Multitude of spores in a single grain—The way in which the seed wheat becomes affected by bunt—Methods of dressing the seed—Alkaline ley the most effectual—Lime, matters containing ammonia, potash—Objectionable substances for dressing—Importance of dressing barley—Fungi attacking other plants in the same way that bunt and smut attack wheat—Notion of farmers respecting fungal diseases in wheat being caused by the berberry plant.

THE fungus now to be described affects only the grain, and is one of the most common diseases to which wheat is subject. Unless, indeed, the precautions that will be pointed out are taken to prevent it, scarcely a field will be found free from its encroachments, which often extend to a most injurious degree. The botanical name of this fungus is *uredo foetida*, or stinking rust, so called from its most disgusting

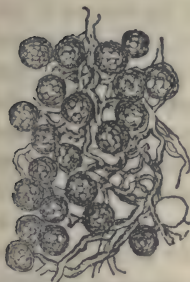
odour, which may be perceived on passing through the field where it prevails ; and if an ear or two be broken in the hand, the smell is intolerable. It resembles the stench of putrid fish, and adheres to the fingers, from which it is not easily removed. The farmers, as usual, have given it a variety of names, as bladder-brand, bunt, pepper-brand and sometimes smut ; which, however, properly belongs to the last-described fungus. The *uredo fætida*, or bunt, its most general name, confines its ravages to the grain, completely filling the seeds it enters, and replacing the flour by a black disgusting fetid powder. This powder is a mass of spores. To examine them, open an infected grain, which is easily distinguished by its rounded, scaly, and dead appearance. The black matter will be found to have occupied the whole interior, and may be now looked at with the microscope. As in the case of the other fungi, take a very small quantity, and lay it on a strip of glass with a globule of water. Over this place a bit of the thin glass previously alluded to as useful in microscopic examinations. This will prevent a lens of high power touching the water. If considerably magnified, the spores present the appearance of a number

of spherical fungi on their *mycelium*, or spawn, as they are here accurately drawn from some specimens given to the artist, Mr. Leonard, for that purpose. The group below shows the fungi magnified 375 diameters, while the single spore above is magnified 1,000 diameters ; and the thread of mycelium is also magnified to the same extent.

Single spore magnified
1,000 diameters.



Small as these spores are, they are much larger than those of the *uredo segetum*. When a spore has been magnified 1,000 diameters, it has been seen by some microscopists to emit a cloud of sporules, but so small that no definite forms could be distinguished. The mycelium is remarkably well shown in these diagrams ; and every person who examines this fungus with an eighth-of-an-inch achromatic, may very readily see the pedicels by which the spores are attached to it.



Group of *uredo foetida*
magnified 375 diameters.

This uredo was very carefully examined by M. Bauer, and his drawings of the various points of interest in which it should be viewed are made with his accustomed skill. He has not, however, shown the mycelium as it is shown here. Opinions seem in favour of the entrance of this fungus by the spongioles of the roots, and of their being propelled through the tissues by the ascending sap, as was stated in the case of the *uredo segetum*. This question will be discussed presently. It is when it enters the young ovum that it finds a suitable place for vegetating. When once there, all fecundation is destroyed by it; there is no development of the parts of fructification, and no embryo whatever can be detected. Still the grain swells on; and when the harvest is cut, the diseased grains are actually larger in circumference than those which are sound. Before they assume their final brown hue, the diseased grains are of a very dark green colour, and emit, when broken, the peculiar fetid smell previously mentioned. Singularly enough, the stigmata of the flowers are not destroyed.

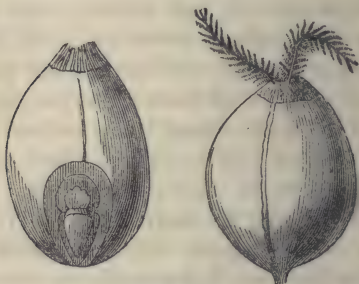
M. Bauer's remarks on the progress of this fungus are well deserving of a place in every treatise upon it. He says, "The earliest

period at which I discovered the parasite within the cavity of the *ovule* of a young plant of wheat (the seed grain of which had been inoculated with the fungi of *uredo foetida*, and sown the 14th November, 1805,) was the 5th of June, 1806, being sixteen days before the ear emerged from its hose, and about twenty days before the sound ears, springing from the same root, were in bloom. At that early stage, the inner cavity of the ovum is very small, and, after fecundation, is filled with the albumen or farinaceous substance of the seed, and already occupied by many young fungi, which, from their jelly-like root or spawn, adhere to the membrane which lines the cavity, and from which they can be easily detached in small flakes, with that spawn. In that state their very small pedicels may be distinctly seen. At first, the fungi are of a pure white colour; and when the ear emerges from its hose, the ovum is much enlarged, but still retains its original shape; and the fungi rapidly multiplying, many of them have then nearly come to maturity, assumed a darker colour, and having separated from the spawn, lie loose in the cavity of the ovum. The infected grains continue growing, and the fungi continue to multiply till the

sound grains have attained their full size and maturity, when the infected grains are easily distinguished from the sound ones by their being generally larger, and of a darker green colour ; and if opened, they appear to be filled to excess with these dark-coloured fungi. But

A healthy grain of wheat.

A grain of wheat affected by the *uredo foetida* with which it is filled.



the grains infected with the *uredo foetida* very rarely burst, and these fungi are seldom found on the outside of the grain ; but if a grain be bruised, they readily emit their offensive smell, which is worse than that from putrid fish. When the sound grains are perfectly ripe and dry, and assume their light brown colour, the infected grains also change, but to a somewhat darker brown, retaining, however,

the same shape which the ovum had at its formation, the rudiments of the stigma also remaining unaltered."

The sketches here given will convey to the reader a correct idea of the form assumed by the grain when occupied by this fungus. The dark green colour of the infected grains is merely a common effect of the presence of the mycelium of fungi. Mr. Berkeley, in a note to his masterly paper in the Journal of the Horticultural Society on the disease of the potato, remarks—"It is well known that the presence of the mycelium of fungi acts as a stimulant to the chlorophyl : witness the rich tint of fairy rings. A curious instance has, within a few days, fallen under my notice. The hazel leaves, a week or two back, were very generally spotted with dark patches of green. On examination, it was found that the reverse of such patches was covered with *erysiphe guttata*, which had been living at the expense of the paler portions of the leaf, while in the subjacent part the *chlorophyl* had become of a deeper green." The *chlorophyl* is the term applied by botanists and vegetable physiologists to the green colouring matter of leaves.

The question whether the fine contents of the

spores of bunt, *uredo foetida*, as well as those of smut, or *uredo segetum*, enter by the roots and circulate in the plant, has already been glanced at. This has been the surmise of most observers, but no one has yet seen them grow ; nor would this, as is stated in the first chapter, be the normal mode of growth. The spores themselves are undoubtedly too large to enter either by the stomata of the leaves, or the spongioles of the roots. Some ingenious experiments have been recently made by Mr. Berkeley, which he most kindly communicated to the author, that appear to establish the theory that these contents of the spores do enter the plant in the way suspected, and grow. The mode of proceeding was to immerse some seeds of wheat in water containing bunt. One of the first appearances was a curious mould with peculiar spores that sprung up on the spores of bunt. The plants which came up from these seeds were evidently affected ; but no communication whatever could be traced between the cells of these plants and the shoots thrown out by the spores. No intrusion whatever of the mycelium developed by the bunt spores into the wheat could be discovered. This looks, therefore, as if the fine contents of

the spores do certainly propagate the fungus. Some writers have called these kinds of fungi growing in the interior of plants *entophyta*, or plants within living substances, as *entozoa* is made to designate animals living within them. Fries says, these *entophyta* never grow in living animals, but this is clearly a mistake, as several kinds of moulds have been found in various parts of them. The whole subject is one of the most curious that can be conceived.

To return to the bunt ; we may observe as before, that of the multitude of its sporules or fine contents no adequate conception can be formed. One grain of wheat is capable of containing four millions of spores ; it is therefore beyond all calculation what quantity of sporules these may send forth. Care of the seed is the only way to prevent the encroachments of this pest, which will otherwise appear in almost every field of wheat. The way in which this happens, is by most writers on the subject, considered to be that when the grain is threshed, or from other causes, the bunted seeds are ruptured, and the cloud of sporules then escapes. They are of a greasy, oily nature, and consequently adhere to the skin of the sound grains. It is quite certain that the disease may be at

any time propagated by rubbing sound wheat against that which is infested by the fungus. If, then, the seed be sown in this condition, the result may be easily predicted. The method also of counteracting the evil at once suggests itself. It is merely to cleanse the wheat which is about to be sown, from all the bunt which may have attached itself to it by reason of its unctuous character. The principle of effecting this object clearly must be, to use means to convert the oily matter which causes it to stick obstinately, into a saponaceous, or soapy matter, which will allow it to be readily washed off. Chemistry here comes to our aid. An alkali will convert oil into soap ; and this is the basis of all effectual *dressing*, as it is called, of the seed-corn. Almost every district has its peculiar dressing, but the best are merely modifications of this principle. Whatever other ingredients may be used, the effective constituent is some alkaline matter in the form of a ley. Lime, which possesses alkaline properties, has accordingly been not unfrequently resorted to : it must not however be too much slaked in mixing, or it loses these properties, and thus often fails. Common potash, and substances containing ammonia, as

for example, the liquid excrements of animals, have been adopted for remedies. Some persons employ brine, sulphate of copper, arsenic, and other things not possessing alkaline qualities. Whenever these methods succeed it cannot be for the reasons advanced, but it may happen that they destroy the vegetative powers of the fungi, though they still remain fixed to the grain. It would be well to follow the advice given by professor Henslow, and to institute a set of experiments on these points. They are curious and interesting questions; and indeed many things relating to these fungi still require minute and accurate investigation. It is unquestionable, however, that a good dressing of an alkaline ley thoroughly applied, completely arrests the evil. Whatever may be the views of some as to the value of sulphate of copper, it is obvious that the application of arsenic is undesirable, and indeed improper, from the dangers attendant on the use of so violent a poison. Nor are such things necessary, on account of the efficacy of the dressings upon the principle before mentioned. Indeed, in the fields of careful farmers, bunt has happily become rare.

It is difficult to apply the same precaution

against the smut, or *uredo segetum* with equally good effect, because the scattering of the spores at an earlier season diffuses them extensively. But barley fields, where they often adhere longer than in wheat, ought to be more attended to than they are ; for a great quantity of this grain is almost every year destroyed by it. As knowledge advances, it is to be hoped the prejudice which leads some to regard the appearance of this fungus with the complacency before mentioned, will be removed. It may happen that the state of the atmosphere which is favourable to its development, tends to a good yield of barley ; but it should be remembered that every ear so destroyed is a loss of superior corn. By all means dress barley where there has been much smut the previous year. In this year, 1846, it is most lamentably prevalent.

With regard to the *uredo foetida*, although judicious dressing has been found to check it to such a beneficial degree, that it is considered to be bad management to have much of it on any farm, it still abounds in districts where the agriculture is of an inferior kind. It is also found to prevail more in the spring than in the autumn sown wheats. The safeguard is the perfect purity and cleanliness of the seed.

When mixed with the flour it is excessively disagreeable; but whether it is injurious to health is not quite decided, though it probably does produce ill effects on the constitution.

No other corn plant but wheat is affected by bunt in this country, but there are several fungi in existence attacking seeds of cultivated plants in the same way. Wheat does not afford a solitary instance of this kind of disease. Lately, in Africa, near Algiers, there has been found a *uredo*, which destroys the seeds of a species of Lucerne just as bunt does wheat. We might also enumerate eight or nine other kinds of vegetables which have their parts of fructification utterly ruined by different *uredines* analogous to those producing smut and bunt in corn. The maize is subject to a large *uredo*; the *panicum* of Egypt has its parasite also in the shape of *uredo*; while another kind enters grasses, and is propagated within the sheaths.

Almost every farmer will say, that wherever the berberry-tree grows it produces fungal diseases in corn. The common fungus on the leaves of this shrub is the *æcidium*, and it looks, at a casual glance, very much like the rust, or *uredo*, of the rose, when it comes in large

patches ; but examine it with a good microscope and the form is quite different. It has nothing in common with any uredo, except that it belongs to the same order. If the contents of its spores do affect corn, the fungi must be altered by being transferred to a new place of growth. It will be well worth the while of the scientific reader to examine Corda's exquisite drawing of the *æcidium*, in his "Icones Fungorum, or Figures of Fungi;" he will gain more by this means at a glance, than he could from pages of description. The berberry also is attacked by *erysiphe*, but no uredo can be conceived to arise out of the sporules of a fungus so entirely distinct from it in every point of view.

CHAPTER V.

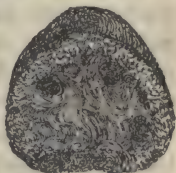
Blights caused by animalculæ and insects—Those to be here noticed true parasites—Blight called ear-cockle, pepper-corn, or purples—Why called peppercorn—Appearance of an affected ear—Contents of a diseased grain—Its similitude to a cottony mass of fibres—Moistened with water, it is found to be a mass of eel-shaped animalculæ—Hence called *vibrio tritici*, or eel of wheat—Account of it in Baker's work on the Microscope—Mr. Bauer's observations and drawings—Vibrio belongs to the class Infusoria—Natural history of the vibrio—Its eggs—The way they enter the plant—Length of time the vibriones retain vitality—Best method of examining them by the microscope—Remedy—Surprise on seeing them for the first time.

THE fungi described in the previous chapters are those to which the principal fungal diseases of wheat are due; and that portion of this treatise being completed, it is time to proceed to the consideration of the ravages of certain minute animalculæ and insects whose effects are known to the farmer, without his being generally aware of the real character of the causes which produce them. The blights of this kind proposed to be investigated are such as are the results of the attacks of true and extremely small parasites. For the notice of

other destroyers of the wheat there is no space; nor is it necessary, since they are within the reach of common observation, and do not require the aid of the microscope to reveal them. The first insect to be brought before the reader is one of the most singular of living creatures; and were its habits not thoroughly investigated and proved, they would seem almost incredible. Its attacks are confined to the farinaceous portion of the grain, which it destroys and replaces, producing the diseases known by the name of ear-cockle, pepper-corn, or purples. A grain of wheat infected by this blight assumes the appearance of a black pepper-corn, whence the second name is clearly derived. The whole ear is altered in appearance: the chaff husks open, and the awms become curiously twisted, so that such ears are easily distinguished from the healthy crop. The grains first turn dark green, and then black; and, as has been said, look exactly like little black pepper-corns. If one of them be divided into two with a pen-knife, it will be found completely filled with a dense white cottony mass, occupying the place of the flour, and leaving merely a little glutinous matter. These contents seem to the eye like a quantity of fibres, closely packed together

in parallel directions ; but if a little morsel is taken on the end of a pin, and put on a slip of glass and moistenéd, it will soon be seen to divide, and give a milky appearance to the water. But, on submitting it to a powerful microscope, the astonished observer will soon discover that the cottony mass is a dense body of living eel-shaped animalculæ, which often wriggle about with great vivacity.

Accordingly the name given to the disease is *vibrio tritici*, the eel of the wheat. The annexed diagram is a faithful representation of a grain of wheat cut across when occupied by these *vibriones*, and the downy mass as is seen, filling the interior.



Transverse section of a grain of wheat filled with *vibrio tritici*, magnified ten diameters.

In the other drawings, the eels are seen, as they are viewed



Egg with the vibrio coiled up, magnified 200 times.



The vibriones, magnified 130 diameters.

by the microscope, magnified 130 diameters,

and also the egg of one of them, with the young vibrio coiled up in it, magnified 200 diameters; to which reference will be subsequently made. Although it is only within the last four or five years that the attention of our men of science has been awakened to the real nature of this curious insect, for which we are more particularly indebted to professor Henslow, its real character was not unknown to observers of the last century. In an interesting publication, which came to a second edition in 1764, entitled, "Employment for the Microscope, etc.," by Henry Baker, fellow of the Royal Society, this vibrio is noticed. His remarks on it are as follow: "The discovery of a certain kind of *anguillæ*, or animals resembling eels, in blighted wheat, was accidentally made by my very ingenious friend, Mr. Turberville Needham, in the summer of the year 1743, in the manner described by himself in his curious book of New Microscopical Discoveries. These animalculæ are not usually lodged in such blighted grains of wheat as are covered externally with soot-like dust, whose inside is likewise frequently converted into a black powder; but abundance of ears may be observed in some

fields of corn, having grains that appear blackish, as if scorched ; and such, when opened, are found to contain a soft white substance, that, attentively examined, seems to be nothing else but a congeries of threads or fibres, lying as close as possible to each other in a parallel direction, and much resembling the unripe down of some thistles, on cutting open the flower-heads before they begin to blow. This fibrous matter discovers not the least sign of life or motion, unless water be applied to it ; but immediately on wetting, (provided the grains of wheat are newly gathered,) the supposed fibres separate, and prove themselves to be living creatures, by motions that at first are very languid, but gradually become more vigorous, twisting or wriggling themselves somewhat in the manner of eels in paste, but always much slower than they, and with a great deal less regularity ; for in them the head and tail are constantly moving contrariwise, and alternately, with the same kind of bending or undulation in the bodies of them all ; whereas the animalculæ we are now describing have no uniformity in their motion, but bend their extremities sometimes differently, and sometimes in the same direction.

If the grains of wheat are grown dry by keeping, and you cut them open in that condition, the fibrous matter is very distinguishable, and, on putting water to it, will separate with great readiness, and seem like fine tubes or threads tapering at both ends; but not the least motion or symptom of life will be perceived till they have been in water for some hours; nay, frequently they will never revive or come to move at all. But if the same grains be steeped in water for some hours, or buried for three or four days in earth, till they are fully saturated with moisture, and then opened with a penknife, on taking out a small portion of the white matter carefully, and spreading it thin upon a slip of glass, the animals may be seen bundled together, and extended longitudinally, but without motion; and though, upon the application of water, they will not revive so soon as those taken from fresh grains, whose moisture has never been exhaled, yet, after abiding an hour or two in water, we have constantly found them alive and vigorous; and that notwithstanding the grains have been kept in a dry condition even for some years, of which I have a remarkable instance now before me.

“In the month of August, 1743, a small parcel of blighted wheat was sent by Mr. Needham to Martin Folkes, esq., President of the Royal Society, with an account of his then new discovery; which parcel the president was pleased to give me, desiring I would examine it carefully. In order so to do, I cut open some of the grains that were become dry, took out the fibrous matter, and applied water to it on a slip of glass; but could discern no other motion than a separation of the fibres or threads,—which separation I imputed wholly to an elasticity in the fibres; and perceiving no token of life, after watching them with due care, and repeating the experiment till I was weary, an account thereof was written to Mr. Needham; who having by trials of his own found out the cause of this bad success, advised me to steep the grains before I should attempt to open them; on doing which I was very soon convinced of his veracity, and entertained with the pleasing sight of this wonderful phenomenon. Since then I have made experiments, at different times, with grains of the same parcel, without being disappointed so much as once; and particularly on the 4th day of July, 1747, finding some of the same parcel left, I soaked

a couple of grains in water for the space of thirty-six hours; then believing them sufficiently moistened, I cut one open, and applying some of the fibrous substance to the microscope in a drop of water, it separated immediately, and presented to my view multitudes of the *anguillæ* without the least motion or sign of life. But experience having taught me, by former trials, that they might notwithstanding possibly revive, I left them for about four hours, and then examining them again, found much the greatest number moving their extremities pretty briskly; and in an hour or two after, they appeared as lively as these creatures usually are. Mr. Folkes and some other friends were witnesses of this experiment."

There can be scarcely found a more interesting microscopical object than these vibriones. Mr. Baker's account of the phenomena they exhibit is as accurate as possible. Curious as the whole matter is, and well as it has been described by him as witnessed almost a century ago, modern microscopists have been as much surprised as he was by these sights, which any person possessing a tolerable instrument may readily enjoy.

The vibriones did not, however, escape the

notice of Mr. Bauer, who read before the Royal Society in the year 1822, an account of his "Microscopical Observations on the Suspension of the Muscular Motion of the *Vibrio Tritici*." His excellent drawings of this insect are in the British Museum, where, by the kindness of the gentlemen to whose care these valuable specimens of art are committed, they were examined by the author. Some of them have since been used by Mr. Curtis, to illustrate his observations on the various insects affecting the corn crops, published in the sixth volume of the Journal of the Royal Agricultural Society. He considers that the vibrio belongs to the class *infusoria*, and believes with others that its eggs are taken up by the sap, and are hatched in the stalk and germen. When the grains containing the vibriones are sown with good seed, they burst in the spring, and set the animalculæ at liberty. It is stated by the best entomologists, that the eels sometimes reach the size of a quarter of an inch in length, and that, at a short distance from the extremity of the tail, they have discovered an orifice whence the eggs issue in strings. The young worms are coiled up in them, as seen in the drawing. Mr. Curtis says, "the eggs come

forth in strings of five or six together, and are detached in water: the young worms can be seen through the transparent skin. In about an hour and a half after the egg is laid in water, the young worm begins to extricate itself; which it took one of them an hour and twelve minutes to accomplish." When largely magnified the head of a vibrio is easily seen, and its curious formation may be observed. It is furnished with a sort of proboscis capable of contraction or extension, like the tubes of a small telescope. The eggs being laid in water, unquestionably facilitates their being taken up by the roots into the interior of the stem; whence the young ones find their way, as soon as hatched, into the nascent ovule before the appearance of the young ear. Although the larger vibriones which lay the eggs after coming out of the bursting cockles reach the size just mentioned, those contained in the grain are exceedingly minute; these are so small, that forty or fifty thousand are computed to be sometimes gathered into the soft stringy mass of a single ear-cockle. The large ones die soon after laying the eggs, while those occupying the infected grains retain their capability of exhibiting signs of active life after

they have been immured for years in their dark and confined receptacles. Kept for six or seven years, and treated as Mr. Baker directs, they will sometimes exhibit considerable powers of motion. It is almost impossible to decide how this vitality can be preserved, but it has been attributed by some writers to the glutinous matter which has been noticed as still remaining in the ear-cockle. Still this is nothing more than a conjecture. To examine them effectually, the observer should soak the cockles in tepid water for about a couple of hours before they are divided: they will then generally be found very lively, and may be kept in that condition a good while in a little water. Indeed, it is possible to preserve them in this way for several weeks, and keep them ready to show: but if the person to whom they are to be exhibited has never seen them before, the best way is to take them at once from an affected grain, lest so incredible a circumstance as their coming from such a source should be doubted. They are rarely met with in any grain except wheat. In some parts of the kingdom, this disease prevails considerably, while in other parts it is scarcely to be met with at all. Probably the best remedy

would be to soak the seed in water sufficiently warm to kill the vibriones, which cannot stand a high temperature; but it must not be hot enough to destroy the vitality of the good seed. The author has frequently shown them to farmers, and witnessed their extreme surprise. One individual, having viewed them with astonishment, met his miller in the street—"You," said he, "may fancy you know a good deal about corn, but you little know what you often grind;" and it would be well most certainly for those who are conversant with this principal portion of the food of man, if they were better acquainted with its real properties and with its diseases.

CHAPTER VI.

Ergot—Reason of the term—Ergot of Rye and Wheat—Character and appearance—Speculations concerning ergot—Mistaken for a fungus—Thought by some to be caused by the puncture of an insect—By others attributed to the action of a fungus—Remarks of professor Henslow—Sugar derived from ergot—Ergotine—Medicinal value of ergot—Effects of a high temperature, and consequent difficulty of analysing ergot—Ergot in grasses—More common in wheat than has been supposed—Instances in proof of this—Awful effects of ergot taken by animals as part of their food—Experiments, and their object—Ought not to be repeated—Ergot the probable source of many gangrenous diseases—Remarkable cases—Ergot should be picked out of wheat—Search should be made for it in localities where certain inexplicable diseases prevail—Probable effect on cattle and pigs—Drainage, and results—Diseases disappearing in France under precautions against ergot—Want of observation—Preventives—Striking analogy.

BEFORE any description is given of wheat blights due to the agency of more perfect parasitic insects than the infusorial one last noticed, it will be expedient to point out the peculiarities of a most extraordinary abortion of the grain, which has been attributed to various causes. The diagrams will convey a correct idea of its appearance in rye and wheat. It is called *ergot*, which is French for *cock-spur*, from its resemblance to the spur of the male



Ergot of Wheat.



Ergot of Rye.

domestic fowl. The ergotted grain is completely changed both in form and properties, and is one of the most wonderful monstrosities to be met with in nature. The altered grains elongate, turn black, and protrude in the manner shown in the figures, both of which are drawings of actual specimens. Ergot has been the subject of numerous speculations, and it has, by a singular mistake, been actually classed amongst the fungi, to which it bears no true resemblance whatever. A very superficial examination, in the present state of science, is enough to show that this is a great error. Some persons have imagined that it is caused by the puncture of an insect made for the purpose of laying its egg, such as is well known to be the case in certain remarkable excrescences on plants, of which oak apples, and nut-galls are common examples. By such punctures, morbid action is induced, and the results are the excrescences alluded to, some of which are articles of commercial importance and of great use to man. A certain fungus invariably accompanies ergot, and therefore it has been concluded by certain observers that it produces the disease. It is however quite as probable that the fungus is accidental to the

ergot, as that the ergot is caused by the presence of the fungus. "Be the cause of its production," says professor Henslow, "what it may, the ergot is a monstrous state of the seed in which the embryo, and particularly one part of it, is preternaturally enlarged, protrudes beyond the chaff, and often assumes a curved form somewhat resembling a cock's spur, from whence the name "ergot," which is of French extraction. It is black superficially, and of a spongy texture internally, containing much oily matter, so that it will burn like an almond when lighted at a candle." Daniell, in his table of sugars and their congeners, says that a certain saccharine matter, which he calls "mushroom sugar," is derived from ergot, consisting of twelve equivalents of carbon, thirteen of hydrogen, and thirteen of oxygen. Another chemist announced, that he had discovered in it a non-azotised vegetable substance, which he denominated *ergotine*. It is obtained in the state of a brown powder, of a pungent and bitter taste, and he looks upon it as the active principle. He says that it is narcotic and poisonous, but the composition and properties do not yet seem to be ascertained; and most probably, if it could be duly examined, it would turn out to

be a mixture. Unquestionably ergot contains oily matter and a saccharine principle, and when taken into the system, its effects are extremely violent. The use of ergot of rye as a medicine, in peculiar cases, has long been well known to the faculty, and recently ergot of wheat has been found to be even more potent than the other. A high temperature, as is the case with most vegetable poisons, destroys its injurious properties, and the rapidity with which such substances become volatile, presents a serious obstacle to its being accurately examined in the laboratory of the chemist.

In certain places, ergot is extremely common in rye, and it is more so than has been suspected in wheat. It occurs in many grasses. In 1844 and 1845, it was abundant in the following grasses—*lolium perenne*, *lolium arvense*, *festuca pratensis*, *phleum pratense*, *dactylis glomerata*. In the *lolium* it was extremely abundant, so that the author can say, he scarcely examined a field either in the east or west of England, for he tried many in both, without speedily finding specimens. There are localities in which the ergot has not been seen at all in wheat, and we find botanists accordingly

who state that they never met with it. But the same individuals would, perhaps, in other places, discover more than they wish to find. Professor Henslow desired his miller to search for him in two bushels of rye wheat, and he quickly produced three dozen specimens, and said there was as many more left in the sample. The author in 1844 suspected the existence of ergot in certain low lands in a village near Great Yarmouth, and requested the miller of the place to look into the corn when sent to be ground from one particular farmer, on a very small occupation near the marshes. The miller soon received from this place four bushels of wheat, and on searching found directly forty-eight specimens, which he brought to the author. The following season the author searched in a wheat field on the same little farm, and could not find any ergot in it; but gathered a large quantity in the grasses growing in the same district, in places where the drainage was bad.

The medicinal effects of ergot, in small doses, have already been noticed as being extremely powerful, but if taken to any extent its results on the animal frame are truly awful. This has been proved by numerous experiments, of

which professor Henslow gives a most striking account in his valuable notice of this disease; to which he adds a proper caution against their repetition now the question is settled. Animals which refused ergot mixed with their food have been compelled to swallow it, and it reduced them to a wretched condition. It was tried upon pigs, and also upon poultry, and the consequences were sickness, gangrène, and inflammatory action so intense, that the flesh actually sloughed away. In some cases, the limbs rotted off, and no description of animal suffering has ever exceeded the direful ills thus inflicted. These experiments were made with a view to determine whether the ergot of rye, constantly ground up with the flour in some parts of France, might not be the cause of the gangrenous diseases so prevalent amongst the poor in certain districts. The symptoms of these epidemic diseases are dreadful, and there seems to be very little doubt that the suspicions as to their originating from ergotted flour of rye are correct. Tessier, who has paid great attention to the subject, mentions a case which came under his own observation. A family were in a state of great destitution, and the father begged of a neighbouring farmer a

quantity of ergotted rye to supply the urgent calls of his distressed family for food. The farmer gave it him, but added that he was afraid it was not wholesome. Still the calls of hunger prevailed, and in the face of this caution it was eaten. The result was the death of the father, mother, and five of the children out of seven. Two survived, but one of them became subsequently deaf and dumb, and, besides, lost a limb which actually rotted off, precisely in the same way as the limbs of the animals which were compelled to swallow the experimental ergot. Professor Henslow has published a series of remarkable extracts from the parish register of Wattisham, in Suffolk, in the year 1762. It records the sufferings of several persons from an unusual species of mortification in the limbs, the symptoms of which were very similar to those of the people under the influence of ergotted rye in France. Indeed there seems a great probability that their maladies were due to the same cause, except that, in the Suffolk cases, the ergot was that of wheat instead of rye. Wherever it is perceived in samples of wheat it ought to be carefully picked out, and might be sold to medical men, since in judicious hands

it may be applied medicinally with great success. But it should never be made use of, except when prescribed by those who are, from profession and practice, well aware of its properties, and skilled to apply them when required.

The whole range of our physiological knowledge does not afford a more wonderful instance of a natural chemical transmutation, under certain circumstances, than the present. By the agency of some unknown cause the nutritious corn is changed into an altered unsightly form, and endued with properties perfectly the reverse of its original wholesomeness.

It is more than probable that many disorders have been produced by this curious abortion, the origin of which has hitherto remained unsuspected. Let search be made for it in localities where gangrenous diseases of the limbs abound, with a view to prevention. Moreover, it is well worthy of the farmer's attention, inasmuch as his cattle may have suffered much from the same cause, when he has never even dreamed of its existence. The author knows, at this moment, of certain low meadows, where all the cattle that were turned into them at one time, were sure to be taken ill. They have been

since judiciously drained, and in 1845 were searched in vain for ergot in the grasses. But in places adjacent the author gathered large quantities. These meadows now afford excellent food for the cattle, and no complaint appears as heretofore, when the occupant was actually afraid to turn any animal into them. Although this fact may not be perfectly decisive, it affords a strong presumption in favour of the idea that ergot did greatly tend to promote the evils complained of. A careful examination of the grasses growing near many hedge-rows, will enable an inquirer in the autumn to discover more ergot than he may imagine. In 1844 and 1845, there was a great deal to be found in such places; and it is notorious to numbers that pigs running about the lanes became diseased.

These inquiries are undoubtedly of great importance, and their value is further enhanced by the fact, that there is reason to believe that in some localities in France, where pains have been taken to prevent ergot being sent to the mill with the good rye, the epidemics formerly so prevalent have diminished. Indeed, it is said, that they have been nearly removed by this judicious care. It is to be hoped that this

matter will receive more attention in parts of our own country, where morbid and unaccountable disorders prevail amongst the poor. Ergot is not unlikely to be the unsuspected source of much suffering hitherto baffling inquiry.

The specimens of ergot of rye drawn for this section, were gathered by the author in September, 1845, in a sort of peaty soil, with a stiff cold subsoil. The rye was late, and pretty nearly every other ear was more or less ergotted. In the previous September, he found exactly the same thing in the next field. The general opinion seems to be, that any wet hard land is suitable to its development. But the singular thing is, that so few people notice it. Threshers in barns will declare they never saw it, till it is pointed out to them. A farmer of great activity, eighty years of age, assured the author he had never seen it. He soon gathered a piece of ergotted rye-grass, and showed it to the old man, who said, "Well, in all my life, I never saw such a thing before!" Indeed, by the men who work in our barns, it is probably often mistaken, when on the floor, for the dung of rats and mice, which it not a little resembles.

The prevalence of ergot in those fields where the drainage is imperfect, and its disappearance

from such as have been thoroughly well drained, seems to point to this as its chief preventive. After searching in vain over a large well-farmed parish for ergot in wheat, during the autumn of 1844, the author requested a small farmer to look over some that was grown on a wet clayey spot close to a ditch adjoining a marsh. He was soon presented with three or four specimens from the suspected place, one or two of which had the chaff scales still adhering to them. This seems to confirm the supposition as to its favourite localities, and at once to suggest the best method of getting rid of it. Professor Henslow appears to be of the same opinion, and hints that when ergot is wanted for medicinal objects, it might probably be always obtained if grown where such conditions of soil present themselves.

The fungus, before said to accompany the disease, and to which it has been attributed, is called *ergotetia*. The mere fact, however, of coincidence, does not prove cause and effect. It has a nasty smutty appearance, and the author has seen the *cladosporium herbarum*, previously noticed, growing with it on the chaff scales of the ergotted ears of rye. Such a transmutation of nutritious

bread-corn into a violent poison, cannot fail to remind the reflecting reader, that the scriptural statement of the word of truth—the seed of eternal life, becoming a “savour of death unto death,” instead of “a savour of life unto life,”—has a striking analogy in this extraordinary natural phenomenon.

CHAPTER VII.

Frequent occurrence of shrivelled grains in samples of wheat—Often caused by the wheat midge, or *cecidomyia tritici*—The time for seeing this fly is June, in the evenings—Its occupation of laying its eggs in the flowers—Larvæ or maggots from these eggs injure the young ovary—These maggots may be easily found in the ears—Mistakes respecting them—The midge a real parasite—Want of information amongst farmers respecting it—Well described by Mr. Curtis—Long ago observed by Mr. Kirby—His view of one laying its eggs—Peculiarities of the larvæ—May be found in the chaff dust of wheat in barns looking like chrysalides, but are only larvæ, covered with a membrane—Chrysalis state probably not reached till spring—Failure of attempts to breed the midges—Curious entomological question respecting them—Importance of deciding it—Estimate of losses by the midge—Remarks—American wheat midge, or Hessian fly.

REMARKABLE as are the diseases prevalent in the wheat, which have been treated on in the last two chapters, they are scarcely more interesting objects of inquiry than the curious devastator of the growing crops to which attention is now about to be directed. Every farmer knows the loss that he constantly sustains, from the large mixture in his samples of shrivelled and defective grains. This continually happens, even when the blossoming

plants have promised to yield the most healthy produce, and all his prospects have been as bright as possible. Harvest, however, and the threshing season, have disappointed him, and the reason of the defect in the corn has been completely wrapt in mystery. The researches of the entomologist here come to aid him in the discovery of his hidden unsuspected enemies, and demonstrate to him that the defect is frequently due to an insect which, though myriads of them may have existed in his fields, he has never seen or heard of. It is a true parasitic fly of singularly beautiful formation, and its scientific name is *cecidomyia tritici*, or wheat midge. The time to see these midges is in the month of June, from seven till about nine o'clock in the evening, when they often swarm amongst the then blossoming ears of corn. They may be discovered busily engaged about the flowers, and their occupation is laying their eggs in them. Here the eggs produce little yellow maggots, or larvæ, which injure the young ovary, and consequently prevent the grain from attaining its due growth and swelling to its natural dimensions. These maggots are easily found in the ears when the grain is formed, by pulling back the chaff scales. The

author for several years past has certainly found large numbers of them, and they have been often brought for his inspection, by farmers who have searched for them at his suggestion. They are mostly accompanied by an orange-coloured dust, which is merely the red robin, with which the reader has been made acquainted in a previous chapter. One farmer imagined that these larvæ were of great use in feeding on this fungus. This was a natural mistake for an unscientific person ; but it tends nevertheless to prove to more experienced investigators how cautious they should be not to connect things with each other, simply because they are coincident. The wheat midge lays its eggs in the wheat, breeds in the ear, and does the mischief before noticed. It is therefore, according to the definition given in the first chapter, a real parasite. Though incalculable damage results from its ravages, a description of it will most likely be a novelty to many readers who may have suffered greatly from it, and who are not acquainted with what has been written on the subject.

By far the best account of this curious fly is that of Mr. Curtis, in his admirable papers published in the Journal of the Agricultural

Society. It appeared in the second part of the sixth volume. The drawing here given is according to his description, and represents a female with its ovipositor, of which much will be said hereafter. The fly itself is of a pale ochreous hue, and hairy. Its eyes are extremely black, and coarsely granulated, meeting on the



Natural length of
the Midge.
and ovipositor.

Magnified figure of Wheat Midge.

crown, and nearly covering the whole head. It has no *ocelli*. There is no visible indication of a mouth, except a short lip and two feelers. The antennæ are as long as the body; the thorax is of a reddish ochre in colour, and the wings are longer than the body, of a whitish

yellow, pubescent, and beautifully iridescent when seen in repose. The abdomen is short, tapering to a point, and is furnished with an ovipositor, or instrument for laying its eggs, nearly three times as long as the body, the oviduct being extremely slender. Mr. Curtis states that he has never seen the male fly, but has no doubt that he should find in it a different form of antennæ. There is abundant matter, in the whole of the papers of Mr. Curtis on the insects affecting the corn crops, to induce a careful perusal. They bring before us, in a most interesting form, many wonderful facts relating to the economy of these minute portions of the creation.

The venerable naturalist, Mr. Kirby, has long been more intimately acquainted than most others with the habits of the wheat midge. In the summer of 1798, he had a good opportunity of making observations upon it, and in the early part of the year following he communicated them to the Linnean Society in his usual felicitous manner. He saw swarms of them about eight o'clock in the evening, at which time they were busy laying their eggs; but towards nine they had nearly all left the scene of their operations. So numerous were

they, that he noticed a dozen at a time laying their eggs upon the same ear. At the same time, he could not discover one he could pronounce to be a male. The males most likely make their appearance at some other time.

Though seen in such multitudes at night, the morning does not exhibit a single one in action; but they are to be found while reposing on the wheat-stalks. If the growing corn is well shaken, they fly languidly about, a short height from the ground, disturbed but not invigorated. They take their rest low down upon the plant, with their heads pointed towards the sky, in which position they may be readily found. The great business of this singular creature seems to be the safe deposition of its eggs in the florets of the wheat. When occupied in this way, they are not easily moved from their engagement, but may be examined if pains are taken to effect this object. They invariably assume the position most favourable for the insertion of their eggs, by the long ovipositor with which nature has provided them. No indication is afforded by the common appearance of the flies that they are possessed of so curious an instrument, but on pressing the anus of any one of them it may be discovered ;

and they have the power of unsheathing it at pleasure. They are armed with what Mr. Kirby called a long retractile tube, or *vagina*, which unsheaths an *aculeus*, or pointed instrument like a sting, as fine as a hair. This is introduced into the floret, and by it the eggs are deposited upon the interior valvle of the corolla just above the *stigmata*. The accurate entomologist, to whom we owe these observations, has discovered them several times caught prisoners by being unable to withdraw this instrument. He also witnessed the operation of depositing the eggs, after many attempts in which he failed. One day he gathered an ear upon which the flies were actively engaged, and was enabled by the aid of a pocket microscope to view this remarkable process. "I could," he says, "very distinctly perceive the eggs passing one after another, like minute air-bubbles, through the vagina, the aculeus being wholly inserted into the floret." He adds, "I examined this process for full ten minutes before the patient little animal disengaged itself, and at last it was through my violence that she discontinued her employment, and flew away." If all the eggs that are thus layed in favourable seasons were to be hatched, or if Providence

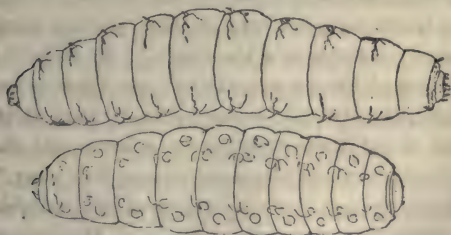
had provided no antidote to their multiplication, the mischief done to our wheat crops would be of the most alarming kind.

The eggs are oblong, transparent, and yellowish, and give birth to larvæ; some of which have at first little or no colour, while others are straw-coloured, yellow, or orange, according to their age. The author found them in abun-



Views of Larvæ of Wheat-midge, magnified 10 diameters.

dance during August, 1845. The natural size of the larvæ is accurately given in the drawing, and also their appearance when magnified ten



Larvæ magnified 20 times. Dorsal and Ventral Views.

diameters. Magnified still farther to the extent of twenty times, the dorsal and ventral appearances were as here drawn by Mr. Leonard, to whom specimens were entrusted for that purpose. These larvæ have been thought by some persons to feed on the pollen, while others think they live on the juices of the ovary. They unquestionably destroy in some way the power of fructification ; for, after their operations have commenced, it is certain that the germen never swells, and complete sterility results. These little maggots, as has been mentioned, are very easily found upon searching in an ear of wheat that has been frequented by the midges. When the corn is threshed they may be discovered in the chaff dust, and look as if they had entered into the chrysalis state. At first sight, those figured here gave this appearance, but they proved to be larvæ covered with a singular kind of membrane. Whoever takes the fine dust on the barn floor in his hand, may easily pick them out, and will perceive them to be exactly of the size given in the figures. A good preparer of objects for the microscope would put some up in Canada balsam, when they might be easily examined. Naturalists who have given

their attention to these insects, are of opinion that the chrysalis state is not reached till the spring, and that the thin membranous covering is a protection against cold till that condition is attained. It is true that there has been one instance of a fly hatched from a chrysalis in September, but this was an exception. There have been many attempts made to breed these flies from the larvæ covered with the membrane, or the supposed chrysalides found in the chaff; but all have failed. It was tried in vain by the writer; but he thought others might have obtained them by reason of more skilful methods, till on inquiry he found they were equally unsuccessful. Conjectures have, as usual, been sufficiently abundant; and a question has been raised, whether the larvæ do not enter the earth to become pupæ, or chrysalides. Certain it is that the membranous cases of the larvæ are found left adhering to the sound grains and to the chaff-scales; and professor Henslow and others assert, that some larvæ have been known to leave the ears and bury themselves in the earth. Any entomologist who decides the question whether these larvæ certainly enter the ground to turn into pupæ, will do great service to science in

general, besides affording information to the farmer respecting the habits of one of the most fatal enemies to his produce when the season is suitable to them. In the author's opinion, the loss in 1845, over some farms, in the county of Norfolk, was considerable ; and Mr. Kirby, several years ago, calculated the destruction in one particular field of wheat which he examined, as at least twenty bushels in fifteen acres. In Perthshire, the loss inflicted by the midge in 1828 was estimated, by a careful calculator, at one-third of the crop. In 1830, an intelligent agriculturist in the north observed, "Another year or two of the wheat-fly will make two-thirds of the farmers here bankrupts." Happily these are not common cases ; but they are such as the agricultural districts are perpetually in danger of, and therefore the farmers ought to be made well aware of the possibility of the encroachments they are liable to when the flies multiply to any great extent. It does not follow, that because in certain years the damage they have done is insignificant, it will be so at other times, when the flies may, perhaps, come in overwhelming numbers, unless a knowledge of their habits enables us always to oppose a

proper check to their increase. "I fear," says Mr. Curtis, "the ingenuity of man will never devise any method for the destruction of this little 'rogue in grain' when once he has taken possession of a standing crop." Professor Henslow likewise remarks, "The researches which I have made on the subject since my report was written, have satisfied me that the damage done by this minute insect is much greater than agriculturists are at all aware of." The author can assert, that in the autumn of 1845, he found great quantities of the larvæ not only in a first-rate wheat district in Norfolk, but in other parts of the country. Ear after ear was gathered by him, examined, and the contents shown to farmers who never before had even heard of such things, and who were perfectly astonished when they saw them. Often has he also entered a barn and taken up a handful of dust from the floor where wheat has been winnowed, turned out the little orange-coloured devourers, now in their membranous cases, one after another, but scarcely ever met with any person who had previously noticed them. If they had seen them, they took them for the seeds of some kind of weed. There seems also to be good reason to suppose that

the wheat-midge is to be found on the continent of Europe, and that it attacks the corn crops in France, causing the same sterility in the grains that has been shown to be the result of its ravages in England. Such facts are of inestimable advantage; for not only do they enlarge our perception of the wonders of creation, but give us an insight into methods by which skilful observers, resident in the country, may confer signal advantages on their neighbours. To dwell upon the history of the habits of a little midge may appear at first sight trifling and unworthy of an enlarged, well-informed mind; but when the benefits on the one hand, and the injuries on the other, of which a multitude of little things are the cause, are considered, we shall soon perceive that the investigation of every single thing made, is a pursuit worthy of not only a rational but of a pious and benevolent spirit, desirous both to give honour to God and to confer benefits on man.

The midge just described in this popular notice, has been properly called the British wheat-midge. There is another midge, of different habits, called the American wheat-midge. It has been designated by entomologists *cecidomyia destructor*, a name which its destructive

ravages entirely warrants. The accounts of the dreadful havoc it had made in the crops in America caused much alarm in this country. Happily for us, this apprehension was groundless. The American wheat-midge usually passes under the name of the Hessian fly, because when it was first noticed, the idea prevailed that the Hessian troops brought it with them in their straw from Germany. The year 1776 was the period of its being observed as committing serious devastations. Indeed, such were the injuries it inflicted on the wheat-crops in America, that a question was raised, whether the culture of this grain could be any longer carried on in security. It seems, however, that the work of destruction does not now prevail to a very great degree. Autumn is the season when these attacks commence : no sooner do the plants appear above ground than they are devoured. Frost causes the flies to desist ; but in the genial days of spring they come forth again. They lay their eggs in the interior of the stem, which is so weakened that it cannot support the ear when the grain begins to swell, and consequently the plant falls and perishes. " All the crops," says Mr. Kirby, " as far as it extended its flight, fell before this ravager.

It first showed itself in Long Island, from whence it proceeded inland, at about the rate of fifteen or twenty miles annually, and by the year 1789, had reached two hundred miles from its original station. I must observe, however, that some accounts state its progress at first to have been very slow, at the rate of about seven miles per annum, and the damage inconsiderable; and that the wheat-crops were not materially injured by it before the year 1788. Though these insect hordes traverse such a tract of country in the course of the year, their flights are not more than five or six feet at a time. Nothing intercepts them in their destructive career, neither mountains nor the broadest rivers. They were seen to cross the Delaware like a cloud. The numbers of this fly were so great, that in wheat harvest the houses swarmed with them, to the extreme annoyance of the inhabitants. They filled every plate or vessel that was in use; and five hundred were counted in a single glass tumbler exposed to them a few minutes, with a little beer in it." This is Mr. Kirby's account; and an interesting description of the fly itself is given by Mr. Curtis, in the papers previously adverted to. We have only to hope this mis-

chievous insect will never appear in England, and have great reason to be thankful that hitherto it is unknown in our island. In the next chapter, a description will be given of the antidotes to the mischiefs of the midges, both natural and artificial.

CHAPTER VIII.

Natural antidotes to the wheat-midge — Benefits of insects to man—Injuries — Beautiful balance of nature—Checks to multiplication of insects — Ichneumons — Why so named — Their general habits—Deposition of their eggs in the larvæ or eggs of other insects—Larvæ of Ichneumons—How they prey on their victims—Regulation of their numbers—Various sizes—Wonderful instincts—Ichneumons glueing their eggs—Ichneumons laying them in nests like cuckoos—Beneficial results from Ichneumons— The Ichneumon of the wheat-midge—Its name; *Platygaster tipulæ*—Curious error respecting it—May be seen in July and August—Method of laying its eggs—Mode by which this operation may be witnessed—One egg layed by it in each larva—Remarks by professor Henslow—Offices of other Ichneumons found in wheat—Flies preying on the midges—Precautions against the midge to be adopted by farmers—Fine sieves—Burning the chaff-dust—Hessian fly— Burning the stubble—Remarks.

THE good providence of God has supplied most remarkable antidotes to the overwhelming increase of what would otherwise be the ruinously destructive hosts of the insects that prey upon the corn, which he has given for the sustenance of man. Science and art have suggested other remedies. It is proposed in this chapter to describe them, for the comfort and benefit of the agriculturist. We derive great advantages

from the insect portions of creation, both direct and indirect. Many necessities, and even luxuries, come to us from these minute sources, and like the fungi, in consuming decomposing matter, they avert the dangers of numerous fatal diseases that would otherwise approach us on the wings of every breath. On the other hand, their encroachments, as in the instances of the wheat-midge, and Hessian fly, fill us with alarms, and threaten the destruction of our harvests. But all things are wonderfully regulated by Him who holds in his hands the balances of nature, though the modes of their adjustment are often hidden from common view, and, to be known, require, like the treasures of spiritual truth, careful research. We have seen what might be apprehended from the wheat-midge in this country, if it multiplied unchecked; nor are persons in general aware of the marvellous antagonism provided against such disasters. Till the entomologist discovered the wonderful habits of a peculiar tribe of insects, called by the common name *ichneumon*, the existence of such a check on the minute devastators of our crops was totally unknown. Ichneumons, so called, are the instruments of this benefit. The term *ichneumon* has been

applied to them, because they are as valuable in their operations for the destruction of insect pests, as the animals so designated are in devouring the eggs of crocodiles and serpents, in the regions where they are the terror of the inhabitants. The little ichneumons of the insect world do as great service as the ichneumons of Africa, which prevent the dangerous creatures just mentioned from becoming so numerous as to occupy the countries where they abound to the exclusion of other animals, and their own misery from want of food.

In order to understand how the curious insects about to be noticed stay the encroachment of our little midges, a few observations are necessary on their general habits. Their peculiar instinct is to lay their eggs in other living insects, mostly when they are in the larva state. Sometimes they oviposit in chrysalides, and occasionally in eggs; but never, it is believed, in any insect while in a perfect condition. The object of their eggs being thus laid is, that they may under these circumstances, which are favourable to their nature, hatch into grubs. These grubs or maggots soon commence attacking the living substances in which they were placed, and ultimately destroy them.

The instinct of these extraordinary creatures leads them to the most complete regulation of the number of their eggs by the size of the victim in each case, and that of the larvæ to which they are to give birth. Sometimes they lay a single egg where there is only enough for the support of its grub, but the numbers vary from one to a large quantity. There is scarcely an insect in existence that is not more or less subject to this species of attack; and the ichneumons themselves vary in size according to the dimensions of the bodies on which they are destined to prey. "Some," says Mr. Kirby, "are so inconceivably small, that the egg of a butterfly, not bigger than a pin's head, is of sufficient magnitude to nourish two of them to maturity; others so large, that the body of a full-grown caterpillar is not more than enough for one." It is not the ichneumon itself, but its larva, or maggot, which destroys such quantities of insects. The ichneumon is a fly with four wings, whose food is honey, and the female seems to live only for the purpose of depositing eggs in the way mentioned. "In search of this," we are told by the aged entomologist just alluded to, "she is in constant motion. Is the caterpillar of a butterfly or moth, the appro-

priate food for her young ; you see her alight upon the plants where they are most usually to be met with, run quickly over them, carefully examining every leaf, and, having found the unfortunate object of her search, insert her sting into its flesh, and there deposit an egg. In vain her victim, as if conscious of its fate, writhes its body, spits out an acid fluid, menaces with its tentacula, or brings into action the other organs of defence with which it is provided : the active ichneumon braves every danger, and does not desist till her courage and address have insured subsistence for one of her future progeny. Perhaps, however, she discovers, by a sense, the existence of which we perceive, though we have no conception of its nature, that she has been forestalled by some precursor of her own tribe that has already buried an egg in the caterpillar she is examining. In this case she leaves it, aware that it would not suffice for the support of two, and proceeds in search of some other yet unoccupied." Such are the singular habits of these creatures, thus aptly described. All these processes are, as might be expected, varied according to the number of eggs that may be placed with a hope of safe existence in any one

body. As soon as these eggs are hatched, the young maggots revel in the feast the body of their victim provides, while the supply of food in every instance is regulated with an inconceivable precision, so as just to last these young ichneumons till they have grown to a size to do without it. Then the grub or caterpillar on which they have existed dies, or, perhaps, just retains sufficient vital power to turn into a chrysalis; which at last does not give birth to a moth, butterfly, or any other fly proper to it, but to several full-grown ichneumons, whose larvæ have become pupæ within this case. The author, not many years ago, had a chrysalis which disclosed, at the proper time, no less than seventeen ichneumons, instead of a large moth which he had expected to see emerge from it. Instinct, we are told upon high authority, is a propensity prior to experience, and independent of instruction. It is verified in those strange operations. The little maggot which springs from the egg of the ichneumon goes on eating up its prey, devouring every part of it except the vital organs, which it never touches, as if it knew instinctively that the death of its victim would involve its own entire destruction by famine. Some ichneumons only glue their

eggs to the bodies of certain larvæ, because their maggots are provided with instruments for piercing the skins. Others, like the cuckoo among birds, lay their eggs in the nests of insects, which hatch them to devour their own young. Bees are particularly subject to such insidious enemies. No concealment, unless perhaps under water, seems sufficient to baffle an ichneumon, and nothing can surpass its perseverance until its eggs are safely placed in the conditions suitable to its progeny.

Great indeed are their services to mankind, in preventing the injuries of the insects which prey upon our corn. "In vain," to use the words of the able naturalist from whose writings quotations have been previously given, "does the destructive *cecidomyia* of the wheat conceal its larvæ within the glumes that so closely cover the grain. Three species of these minute benefactors of our race, sent in mercy by Heaven, know how to introduce their eggs into them, thus preventing the mischief they would otherwise occasion, and saving mankind from the horrors of famine." It would be foreign to the purposes of a popular little book like the present, to enter into the entomological details of the formation and habits of these

creatures. A general view of their operations will be quite enough. The most common of them is a small fly, like all the rest, of the hymenopterous order. It was originally called *ichneumon tipulæ*, but now goes by the name of the *platygaster tipulæ*. A most accurate description, and a drawing of this fly, may be found in the interesting papers of Mr. Curtis, adverted to in a previous part of this volume. The male is black, and the female is of a pitchy colour. Both shine very much; the former is difficult to meet with. Superficial observers, who have noticed the larvæ of the wheat-midge in the ears, have mistaken the ichneumon, which they have observed amongst them, for the parent of these larvæ, and have consequently condemned it as the origin of the very ills it is destined to diminish. This affords another instance of the folly of hasty conclusions, and of the false reasoning relative to the inferences people deduce without accurate investigation, when they merely see two things together. Just in the same way some farmers have concluded that the little ichneumon flies we are now noticing must lay the eggs producing the larvæ of the midge, because they have themselves seen them amongst the corn

containing these larvæ. It is time for all observers to arrive at a better state of knowledge, lest we destroy, as authors of mischiefs, the friendly antidotes to their increase. Prejudice and hasty judgment lead to perpetual misconstructions, as to things both moral and natural.

But to return to the ichneumon. This little platygaster may be readily found on the glumes of the wheat-plants, in the months of July and August. It runs rapidly over the ears, and seems to know well which are those occupied by the larvæ of the midge. The author found numbers of them in various wheat-fields in August, 1845; and almost invariably, on examining the ears on which they appeared, discovered that they contained the objects of their search. The ichneumon hunts for them with the utmost eagerness, and by the aid of a sharp tail places a single egg in each of their bodies. The sight has been witnessed by the following experiment: a number of larvæ of the wheat-midge were put upon a piece of white paper, pretty near each other, and an ichneumon was dropped into the midst of the group. The energy of her manner, the rapid vibrations of her antennæ, and the whole of her attitudes, were most amusing. On approaching one of

the larvæ her agitation quickened to the utmost intensity ; she soon bent her body in a slanting direction beneath her breast, applied her tail to the larvæ, and, becoming still as death, sent forth her curious sheath and deposited her egg in the victim, which writhed considerably under the operation. If she came to one that had previously an egg in it, she left it in an instant and sought another ; for the platygaster lays but one in each. This however, often repeated, destroys a great many of these little devastators of the grain. The observations of professor Henslow confirm those which have been already made. He says, "When these eggs are hatched, the young maggots which they produce, and which are the caterpillars of the ichneumons, feed upon the fleshy or muscular parts of the caterpillar they are attacking, carefully avoiding the vital parts. At length the caterpillar, they have been thus devouring alive, dies ; or, as frequently happens, it changes to the state of a chrysalis before it is destroyed. The ichneumon caterpillars also pass to the chrysalis state, and either remain within the body of the dead caterpillar, or come out before they assume the fly state. Each species of ichneumon is restricted in its attacks to one, or at most to a

few particular species of caterpillar ; and the females instinctively proportion the number of eggs they deposit in each individual to the relative size of their own offspring, and that of the insect on which they are destined to prey." It is impossible to contemplate these habits of the minute insects thus brought before our notice, without being deeply impressed with the omnipresence of the great Being to whom all things owe their existence. The same hand that spread the north over the empty space, and suspended the earth upon nothing, and keeps the stars in their courses, regulates the numbers, instincts, and uses of the smallest living things, appearing equally perfect in all :

" What less than wonders from the Wonderful,
What less than miracles from God can flow ?"

The two other ichneumons mentioned by Mr. Kirby are supposed to limit the increase of the platygaster tipulæ. One of them is said to oviposit in its eggs, the other in its maggots. There are also many other species, opening a wide and curious field of inquiry for the entomologist. Several very interesting drawings of those alluded to here are given by Mr. Curtis, in the paper previously recommended to the reader's careful perusal. One

of these extraordinary flies has an ovipositor, nearly thrice its own length, which it inserts into the parts of the flower containing the eggs in which it designs to lay its own. Indeed the instruments with which nature has furnished all the ichneumons that have been observed, manifest the most remarkable adaptation ; and there could scarcely be conceived a more beautiful subject for a separate treatise than that of their forms and habits, whenever they may have been sufficiently investigated. The design of the present remarks is merely to show how carefully there is provided, by the goodness and wisdom of God, a natural antagonism to the disasters that would befall mankind from the unchecked multiplication of our insect enemies. Nor do the ichneumons alone perform this office. There are flies which live upon the midges, carrying them off and devouring them in the same way as hawks and other birds of prey diminish the numbers of the smaller feathered tribes. While this agency is going on in nature, there is left abundance of scope for the exercise of our own ingenuity ; and the next question is, how we may effectually call it forth in the way of defence against the little pests now under review ?

The author has before stated, that he could not succeed in breeding the midges from the larvæ found in the chaff dust of the barn, and that some of the larvæ have been known to enter the earth. There is, perhaps, reason to believe that it may ultimately be distinctly ascertained that the chrysalis condition is assumed in the earth. If so, those persons who throw this dust carelessly, as is the constant habit, into the farm-yard, help the increase of the fly. The best method of preventing the multiplication of this destructive insect, seems to be that suggested by professor Henslow. He advises the farmers to get sieves made of such a construction that the chaff may be saved, and the dust containing the larvæ pass through. This dust may be destroyed by burning, and with it the larvæ themselves.

The writer has reason to believe that the efficacy of this mode is more than conjectural. In the autumn of 1845, the larvæ of the midge were extremely numerous in the district in which he resides, and several farms suffered considerably. Two intelligent farmers had adopted the precaution of the sieve on large occupations. There were scarcely any midges to be found in their wheat, while in other

neighbouring places they were extremely abundant. This simple precaution might have saved many persons, in certain years, a large portion of their crop.

With regard to the Hessian fly, the advice given by Mr. Curtis is manifestly the best possible. It is well worthy the attention of the agriculturalists in America. Nothing can be more simple. He merely recommends them to collect and burn the stubble in the fields where they have been found; and the reason given is, that the larvæ at the base of the straw will of course be destroyed. The burnt straw will also form excellent manure for the land; and thus a double advantage will be gained.

The fungi and insects that have been described in the preceding pages form the principal parasites of our wheat-plants. Two more chapters will be devoted to some general remarks on certain matters, evidently connected with these inquiries, and tending, it is trusted, to beget further investigations. It is almost impossible to avoid, in such explanations, that kind of phraseology which, from its technicality, appears at first uninviting, and a knowledge of which is assumed in the books and papers of the

learned. Men of science have been frequently more mindful of their own reputation, than of the instruction of the ignorant. Still they ought to descend no farther than is needful to raise the latter up to the proper elevation for useful inquiry, by blending together instructive facts and clear explanation. May it also ever be their desire to point to the grand moral lessons taught by physical facts, and to show that the most striking marvels tend to make us rest more and more in believing confidence in "Him in whom we live, and move, and have our being!" Thus the exercise of our faculties will quicken our faith,—and

"Faith is not reason's labour,—but repose."

CHAPTER IX.

Want of more extensive acquaintance with the minute parasitic fungi—Proofs of this—Untenable notion of spontaneous generation—More inquiry needed into the uses of fungi—The case of the mould called erysiphe—Imperfect knowledge of it, though so extensively prevalent—Botrytis—Botrytis of the potato—Probably not the cause of the disease of 1845—Singularly connected with it—Anomalies—Habits of growth of the potato botrytis—Proof of the presence of its mycelium in the plant and tubers—Progress of sound knowledge slow—Dutrochet's experiments on the growth of moulds—Remarks on them—Remedy for moulds on peach-trees in houses and potatoes in frames—The author's experiments in the spring of 1846—Observations.

IN the first chapter of this little volume, the general habits of the fungi, as far as we are yet acquainted with them, are described at large. It will be interesting, however, to the agricultural reader to hear something more of the peculiarities of those which are found in the fields and gardens of this country. Hitherto but little accurate knowledge prevails respecting them, especially amongst the cultivators of the soil; and even men of science and patient botanical research have much to learn upon

these subjects. In the various publications relating to the progress of that singular disease in potatoes that committed such ravages in the autumn of 1845, remarks were made upon fungi, which showed that the authors of them had made no accurate observations with regard to the real characteristics of these singular pests. Every well-informed botanist at once detected these mistakes, and perceived that no practical advantage could be derived from the advice offered on such erroneous foundations. It has been already stated, that no good reason can be given for their constant appearance under certain circumstances, but the almost universal diffusion of their sporules, whose minuteness renders them capable of abounding in almost every situation. The difficulty is to conceive, floating, as they do, unseen in the atmosphere, how any place can be free from their presence. Nevertheless there have been speculators who, having marked their constant appearance on the same places of growth under similar circumstances, have ventured to conceive that they are the results of what is called spontaneous generation. Such persons think that certain conditions of matter give rise to vitality of the low

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kind found in these fungi, and that the same holds with regard to certain animalculæ and insects. This reasoning is opposed to all the soundest principles of inductive philosophy. The evidence, on the contrary, tends to the conclusion which has been previously announced. Innumerable myriads of sporules, finding suitable matrices, give rise to fungi; and innumerable minute eggs, similarly circumstanced, give birth to the animalculæ which have been attributed to these untenable causes. This opinion is further confirmed by the fact, that fungi are frequently absent when they might have been expected to have abounded. The reason is, that by some means or other the sporules have not found their way to the localities which otherwise indicate the conditions of their growth: consequently the expected fungi have not appeared. Mark the instance of preserved fruits, which generally give rise to certain moulds. If these are covered, no moulds appear; if left exposed to the air, they are almost sure to be developed. In the former case the sporules in the air were excluded; in the latter they found a ready admission. Again; if a match is burned immediately

over a jar of some preserve, the moulds are said not to appear. The reason is, the oxygen has been consumed which has been essential to the development of these fungi, and, if the fresh air be excluded immediately, they cannot vegetate. Inoculation, also, of plants by fungi, militates against the notion of spontaneous generation. The true cause of their appearance is, undoubtedly, the existence in the atmosphere of the sporules as before stated; and when these find a situation of growth adapted to their nature, they vegetate and produce fungi.

The injuries we receive from such fungi are incalculable. We have already seen what mischief is done by them to our wheat crops. The loss to the possessors of silkworms from the same causes is often immense; and the dry-rot fungus, as every one knows, causes excessive damage both in our shipping and in our houses. We have, nevertheless, a grand compensation in the benefits conferred by the various tribes of fungi in clearing away the evils arising from decomposing organic matter. They do this good effectually by their unparalleled rapidity of growth, and by the quickness and facility with which they appropriate the

putrescent effluvia of dead substances, and incorporate it into their own systems. Hereby escape into the atmosphere is prevented, and the consequent spread of numerous diseases. Nor ought the medicinal properties of fungi to go much longer without being further tried. Probably science will hereafter make them available for purposes of which, in its present condition, the practitioner has little or no conception.

So little is accurately known of the habits of minute fungi, even by the most curious investigators, that even the mode of growth of erysiphe, to which attention has been drawn by certain observations, cannot be said to be clearly known. As seen in certain vegetables, the curious fungi bearing this name, spring from a floccose web, and consist of little globules, which change colour as they grow older, generally ending in black. This web is filled with sacs containing sporules. The sacs put out curious fibres, which lift them up from the surface of whatever leaf they may grow on, and whose juices they imbibe as the source of their vitality. Before this appearance takes place there are to be seen threads, white or greyish, and consisting of bead-like joints, the uppermost of which, it has been asserted, fall

off and vegetate on the plant. Abundant specimens may be frequently seen on the leaves of peach-trees. We know that it belongs to the fifth order, (*ascomycetes*,) because a good microscope shows us that its spores are in *asci*, or little vesicles. Mr. Berkeley believes that the various species of this fungus attack perfectly healthy plants. Still no botanist can positively state how it grows on any one of them. The best authorities think that it grows in the form of a mould, which is called by them *oidium*; and conceive that very possibly it makes its first appearance at the stomata. But nobody has found that its mycelium, or spawn, actually gets up into the leaves; for in its early stage it is a jointed mould, seemingly superficial. Now, when we find the hop, the bean, the pea, and the whole series of leguminous plants withering under the triumph of this disease year after year—when it is the pest of our beautiful peach-house, and even rages on some of our finest trees, as the sycamore—what a lamentable state of ignorance prevails, that we can say no more of it than has just been announced. Well might sir Isaac Newton say to Halley, when speaking of science, “There is game in every bush, if you choose to beat for it.”

Take again the various kinds of *botrytis*. There is hardly, on the face of nature, a more common fungus than this. For ages it has met the eye in innumerable fields. The produce is pronounced mouldy: there is an end of it. Scarcely any one has thought of investigating the matter further. In the spring of the present year, (1846,) the botrytis of the vetch threatened destruction to an immense quantity of valuable produce, and this would have taken place had not the sun shone with great power. But ask almost any farmer what it is; he knows no more than those who have never seen it. It is enough for him that the plants are mouldy, and it cannot be helped. But science will introduce us to a better state of things. "Onions are mildewed," says the gardener. Does he know that this mildew is a botrytis, called "Destructor," from its ravages? Another botrytis is found on turnips, and another on nearly all plants where decay has decidedly commenced. Of all the kinds of botrytis, that which appears on the potato is perhaps the most remarkable; and its singular connexion with the disease of 1845, and again in 1846, will render it perpetually memorable. To say that the

disease was caused by this fungus would be contrary to the best evidence, but that it attends and accelerates it is unquestionable. True it is that whole fields, in a sad condition of disease, were seen without a trace of botrytis; but in all contagion, infection, and inoculation, anomalies constantly occur. In most cases, the botrytis was certainly connected with the disease, and a description of its growth will be interesting to every reader. The threads of mycelium interwove themselves amongst the cellular tissue. They ran through the loose intercellular passages of the lower surface of the leaf with great ease, and the fungi emerged through the stomata. Drawings of these modes of growth will be found in Mr. Berkeley's paper, in the first volume of the Journal of the London Horticultural Society. They admirably illustrate the progress of this curious fungus, the mycelium of which was undoubtedly present in the potato plants. It is a remarkable circumstance, however, that this botrytis was found to grow with greater luxuriance on the diseased tubers, where the tissue is far more dense, than in the stems or leaves. That the mycelium of this fungus was contained in the

diseased potatoes may be proved from the following singular circumstance : A quantity of silk was, during the early part of the spring of this year, (1846,) perceived to be greatly damaged by a white mould. On submitting a portion of it, for examination, to an individual eminent for a knowledge of fungi, it was at once pronounced to be the *botrytis infestans*, or mould of the diseased potato. The mystery was soon cleared up ; for the silk had been dressed with starch from potatoes, and proved a favourable situation for the development of the fungus from the spawn that was in it. Growth in such cases is extremely rapid ; and when a potato plant is attacked by the botrytis, of course the juices are consumed by it, the elaboration of sap in the leaves cannot go on, nor, from the stoppage of the stomata by its threads, can admission of air, or emission of any gas or fluid take place. It is certain that the disease which destroyed such quantities of the potatoes in America, Great Britain, and over the continent of Europe, has not yet been satisfactorily explained. Further researches in plants more recently infected may throw additional light on the important subject. Undoubtedly, in most instances the

fungus appeared ; and where it was not actually seen externally on the leaves, it seems to have exercised an influence on the tubers, which are, in fact, branches or stems under ground, as every botanist knows. Several other curious fungi have also been seen in the tubers, which have not yet been fully described.

Enough has been said to show the extreme importance of more complete knowledge of the habits of parasitic moulds, and of the circumstances favourable or unfavourable to their development. It is hoped that what is now about to be detailed on that subject, as the result of experiments, will be regarded as a step in the right direction. Such steps must form the commencement of all useful discovery. Sound knowledge seldom takes a great leap when it first comes amongst us : it enters by slow and sure movements. The light of genuine science first appears as a spark, which subsequently is fanned by industry into a flame ; false speculations, on the contrary, are mostly a blaze of straw.

It is purposed, in pursuing these inquiries, first, to advert to the experiments made by Dutrochet, one of the most ingenious of French

naturalists; and then to describe some that were made by the author, in the spring of 1846.

It may be known that if the sap of certain plants, as the vine for instance, be kept in glass vessels, certain filaments will soon be seen floating in it; but few persons are apprised of the fact, that these filaments are the mycelia of moulds. If solutions are made of gum, isinglass, or glue, the same kind of filaments will appear, and they also are the mycelia of moulds. From these mycelia, or specimens of spawn, there grow two species of moulds, one articulated, corresponding with the simplest form described in the first chapter, and the other having the threads from which they spring entirely destitute of articulations. The articulated moulds look under the microscope like strings of little pearls, and are therefore called *monilia*, from *monile*, a necklace, because necklaces are frequently so constructed. The non-articulated threads pass by the name of *botrytides*, because they produce botrytis fungi of different kinds. Dutrochet, aware of these peculiarities, instituted a set of ingenious experiments with a view to determine the properties of liquids favourable to the development of one or the other. He disclaims at the

outset all idea of spontaneous, or equivocal generation, and attributes germination to the causes to which they have been before assigned by the writer.

The first thing he discovered was, that pure albumen is altogether unfit for the growth of any kind of mould. A solution of white of egg in distilled water, kept for a whole year, yielded no mould whatever, though placed in a damp situation, and in all the other conditions usually deemed propitious. This liquid was then taken, and placed in glass vessels containing an ounce each, and into every one was put a single drop of some acid. The acids applied were sulphuric, nitric, muriatic, phosphoric, acetic, and oxalic. In every case, after about eight days, articulated moulds, of the same microscopic character as common blue mould, with which almost every one is familiar, made their appearance. These beaded threads constantly grew under these circumstances; but if there was added more than a certain quantity of any of these acids, there were no results at all. The mixture was found to be too strong.

It next occurred to Dutrochet to try alkalis, instead of acids. Accordingly he dropped into the solution of white of egg in distilled water,

a little caustic soda, and caustic potash. To his delight, after a longer time than in the other cases, he found that the mould which these mixtures yielded was invariably without articulations. Botrytides were always developed by these alkalis.

Hasty observers would have concluded from these facts that acids exclusively favour the growth of articulated moulds, and alkalis of those which have no articulations. Dutrochet, however, was not disposed to make any such incautious generalization, and tried two more curious experiments.

The first was, to mix fibrine of blood with a little liquor potassæ, or solution of caustic potash, in distilled water. The mould springing up in this case was not a botrytis, as might have been expected, but a beaded mould with articulations.

The next trial was to distil the juice of a lettuce, and to add to the distilled liquid a little phosphoric acid. Here again a result took place contrary to expectation, in the appearance of moulds without articulations. The distilled juice of the same lettuce which was used in the second experiment, when left alone, yielded no mould whatever.

Whenever, on the other hand, the distilled juices of any plants, such as peach leaves, laurel leaves, and others containing prussic acid, were left in a similar situation, they invariably were found to give rise to moulds. The reason obviously was, that the acid passed over in the act of distillation. Every vegetable juice on which experiments were made produced moulds, if it contained any acid whatever, even though not in sufficient quantity to redden vegetable blues, the most easy test of the presence of an acid in any substance. These beautiful investigations were detailed at length by Dutrochet in the "*Annales des Sciences Naturelles*," as long ago as 1834, but somehow did not attract the attention they merited.

The salts of potash in vegetable juices certainly seem, according to these experiments, to be favourable to the development of the mycelium of moulds. It also seems, from other facts relating to this matter, that there is both a maximum and minimum of such salts requisite for preventing or facilitating their growth.

No neutral salts produced any effect; and this explains why albumen yielded no moulds, notwithstanding the soda it unquestionably contains, and which would have induced the

expectation of their growth in that substance. The reason is, the soda in albumen is in the state of albuminate of soda, which is a neutral salt, and therefore, according to the experiments on neutral salts, no development of mycelium could arise from it. It is not unlikely that a closer investigation of these phenomena might lead ultimately to such a course of management as greatly to check the various fungi infesting the vegetable tribes, and therefore they have been brought in this place before the notice of the reader: it will be well if any person who has leisure and talent should be inclined to make experiments with this design.

Not the least curious of these interesting experiments of Dutrochet, were the effects of certain substances which he added to the original mixtures.

When mercury was added in its metallic condition, the growth of the moulds was neither impeded nor accelerated.

Red oxide of mercury, corrosive sublimate, and othersalts of mercury, completely prevented all development of mycelium, and no moulds were seen.

But *Æthiop's* mineral, or sulphuret of mercury, allowed the moulds to vegetate freely.

As oxide of mercury prevented all growth, so oxide of lead, on the contrary, quickened it. The moulds were visible much sooner than before.

Oxides of iron, antimony, and zinc, were completely neutral in their effects. Their presence produced no difference whatever.

Again, oxides of other metals, as copper, nickel, and cobalt, did not entirely prevent the vegetation of the moulds ; but they were much impeded by their presence, so that they grew and spread a great deal more slowly.

The proximity of any perfume always proves a complete antidote to the growth of every mould.

No doubt, upon long and accurate trials, many more curious facts would present themselves, which at length might be reduced to a sort of practical system, conferring great benefit on the community at large. Suffering as we do in our farms, our gardens, and in our houses, from moulds, such discoveries would prove of inestimable value. As an instance, it may be stated that flowers of sulphur dusted over the leaves of peach trees in forcing houses, and potatoes in frames, are found most effectual in preventing the growth of erysiphe on the former, and

botrytis infestans on the latter. Why then may not more general remedies be revealed by experiments and inquiry, if conducted with patience and skill?

In order to verify the statements by Dutrochet, the author was induced to try a few experiments on a similar plan, in the spring of 1846. The results were sufficient to manifest that many curious, if not useful, facts would reward the patient investigator. His proceedings consequences shall now be stated.

He first tried the white of an egg in distilled water, and though he kept it where it was damp and dark for many weeks, not a vestige of any mouldiness appeared. The albumen, as he had been taught to expect, yielded neither botrytis nor beaded mould.

He next filled a small gallipot about half full with the same mixture, and added one drop of pure nitric acid. In the course of eight or ten days the surface was mouldy. On submitting this matter to the microscope it was perceived to be a mass of monilia, or articulated mould.

Oxide of lead was added to a similar gallipot, into which he poured a teaspoonful of the same nitric acid. No mould whatever

appeared. There was too much of the acid.

A drop of sulphuric acid was added to a third gallipot, containing the same solution of albumen. In a month's time mould of the articulated kind began to show itself.

To a similar mixture Æthiop's mineral was added; and, to his surprise, there came an abundance both of monilia and botrytides.

The next experiment was of the same kind, except that the acid was acetic. Plenty of monilia grew on the surface.

Red oxide of mercury added to a gallipot containing the same mixture, totally prevented the appearance of any mould.

Red oxide of lead, on the contrary, quickened the growth of abundance of articulated moulds.

Caustic potash was next tried in the solution of albumen; and there came a quantity of botrytis, or non-articulated fungus, some specimens of which were white, and some coloured, as if tinged with cochineal.

These were all the experiments he had leisure to try, but they are quite sufficient to show what wonderful matters for inquiry are presented by these little fungi, and to create

an expectation that a year or two of ingenious research would give rise to phenomena of the utmost interest to men of science. Nor would practical advantages fail to accrue. No man can say that out of the slightest apparent discovery we may not derive the greatest benefits. The simple circumstance of the deflection of the needle by a galvanic current, carefully observed and stated, has given to the world the electric telegraph. The discoverer of this apparently trivial fact never imagined that it would lead to anything like this. It teaches us to mark every secret nature unfolds to those who diligently inquire into the hidden things of truth. If families could but be persuaded to replace the frivolous amusements, which only promote vacuity of thought, and are no real sources of pleasure, by observations of things in the world in which they move, and would introduce the microscope in the winter evenings into their circles instead of silly games, how would our national taste and knowledge improve! Fortunately, the appetite for such recreations is on the increase, and might become the source of real edification. Philosophy would then be indeed to Christian minds—

“ Effusive source of evidence and truth,
A lustre shedding o’er the ennobled mind,
Stronger than summer-noon, and pure as that
Whose mild vibrations soothe the parted soul
New to the dawning of celestial day.
Hence, through her nourish’d powers, enlarged by thee,
She springs aloft, with elevated pride,
Above the tangling mass of low desires,
That bind the fluttering crowd; and, angel-wing’d,
The heights of science and of virtue gains,
Where all is calm and clear; with nature round,
Or in the starry regions or the abyss,
To Reason’s and to Fancy’s eye display’d;
The *first* up-tracing, from the dreary void,
The chain of causes and effects to *Him*
The world-producing *Essence*, who alone
Possesses being; while the *last* receives
The whole magnificence of heaven and earth,
And every beauty, delicate or bold,
Obvious or more remote, with livelier sense
Diffusive painted on the rapid mind.”

THOMSON.

Some persons may smile at the notion of devoting their inquiries to the habits of a fungus; but fungi are the works of infinite wisdom, and nothing is made by infinite wisdom that has not claims for well-regulated finite intelligence.

Every organized substance is so framed as to illustrate certain great natural laws; and natural laws, well considered and understood, have power to impress on the mind the most striking moral lessons. The falling of an apple

to the ground, by the force of such a law, awakened thoughts in the mind of Newton that unfolded the glories of the solar system and the economy of the universe. Let no one therefore despise what, by a false comparison, we are accustomed to designate small or insignificant, for neither are epithets becoming the creatures of God, as applied to any of those things which he has made and adapted to his own designs. The least thing, even a mould, requiring the highest power of the microscope for its observation, can become in his hands, as we have seen, a mighty scourge or a transcendent benefit. Nothing is so small but that almighty power can accomplish great ends by its instrumentality; nothing is so weak but the strength of God can make it victorious; nothing is so feeble but that out of it at his bidding there issues might. Hence the minutest organized substances which obey the laws which he has impressed upon creation tend to His glory; and the study of them enables us to collect the treasures of real wisdom, and to improve our condition in the world.

CHAPTER X.

Wonderful economy of insects and animalcules—Compensation we receive from insects for their injuries—Commercial importance of insects—their uses in removing decaying organic matter—Adaptation to this object—Reasons of insect transformations—Their amazing multiplication—Larva state—Perfect condition—Different habitations of the same insect in its different states—Injuries to our crops from insects—Wireworms—Elaters—Weevil—Oscinis vastator—Cephus pygmaeus, or corn saw-fly—Thrips—Plant-lice—Palliatives all we can expect—Mistakes as to remedies arising out of want of knowledge—Infusorial animalcules—View of them by the microscope in infusions easily made—Polygastrica—Speculations—Diffusion of the eggs—Curious forms of infusoria—Ehrenberg—Cilia and their uses—Monads—Fossil infusoria—Prevalence of living infusoria—Their multitudes—Proved by experiments to emit oxygen—Liebig—Guano—Uses of infusorial animalcules—Source of pure vital air—Limit putrefaction—Destroyed by putrescent matters and sulphuric acid—Concluding remarks.

THE economy of the minutest insects and animalcules with which we are acquainted is quite as wonderful as the nature of the fungi adverted to in the preceding chapter; while some experiments recently made on the infusoria, to which class the little eels of the pepper-corn of the wheat belong, are as striking

as those that have been described in relation to the growth of moulds. The injuries we receive from insects are doubtless great; but we have our compensation in the benefits they confer upon us. When we look upon some of these separately insignificant portions of creation, their importance seems almost incredible. Who could suppose, on examining a minute cochineal insect, that this nation actually pays about five millions of dollars every year for the myriads of their dried tiny bodies which art has called into use? How wonderful is it to remember, when we may be sealing a letter, that the little gum-shel-lac insect provides for us wax a an appendage to our writing apparatus, and that very large sums are yearly expended on its importation! When we look at a sluggish silkworm feeding lazily on some leaf, and consider it merely as the larva of a plain-looking moth, and perceive its feeble movements and rather sickly aspect, it fills us with amazement to recollect that more than fifteen hundred thousand human beings gain their daily bread from gathering, winding, and manufacturing the web of the cocoon of such a caterpillar! Many other instances might be adduced

to prove that though the insect tribes offer us much annoyance, and inflict upon us frequent losses, we are still largely their debtors. Like the fungi, also, they have assigned to them a most beneficial part in the grand economy of nature; and this is the removal of decomposing organic matter, and thus preventing disease from putrid exhalation. Every maggot that is bred in the dead body of any animal, or the tissues of any rotten plant, is performing this needful and beneficial function. For this purpose extensive powers of multiplication and great voracity, are evidently essential requisites. Hence we may see the reasons of the changes peculiar to the insect world, and of the multitude of eggs the various flies which are parents of larvæ continually lay. Small numbers could not perform the offices assigned them to any useful extent; nor, if insects passed at once into that state in which they are employed in the cares of reproduction, would they be able to carry on the work of feeding on putrid matter as their sole object. Hence we see the wisdom of God as applied to his designs. The design in this case has been explained, and we may perceive the adaptation. It is expedient that these insects, whose

province it is to remove the injurious substances adverted to, should be wholly employed in this work. Accordingly we find these maggots in a state incapable of reproduction, and endued with what they require—an insatiable desire for constant feeding, and proportionate digestive organs. They pass into another condition before they begin the reproductive processes, which must interrupt their operation of constantly feeding on the superabundant and injurious matters which would otherwise destroy the healthiness of the air we breathe. The larva, therefore, has no propensity but a constant appetite for food, and is the longest state of insect life. After this it is changed into a condition of inactivity, wherein, by certain slow processes, the perfect fly is formed, and subsequently disclosed, not to feed with the voracity of its maggot, but to lay multitudes of eggs in places suitable for the development of more larvæ. The object of its existence having been thus answered, it dies. Who can think of these marvellous transformations, and not admire the wisdom and power of God, nor fail to remember for himself, that, before he can perform the services of a better world,

he must be transformed too, and that by the renewing of his mind? The same insect may be said, in certain cases, to live in several different worlds. It inhabits, in its successive conditions, water, earth, and air, while it is fitted for these respective abodes by new organs, instruments, and forms suited to each. Every one has some purpose. Can we have a better illustration of this than in Bonnet's celebrated remark : " Of what riches should we not have been deprived, if the silkworm had been born a moth without having been previously a caterpillar !"

Still the larvæ of many insects do the greatest injury to the produce of the farms of this country. For example, there is scarcely any species of cultivated plant free from their attacks. Wheat, rye, oats, and grasses are largely destroyed by them. These wire-worms are the larvæ hatched from the eggs of certain beetles. " It will probably," remarks Mr. Curtis, " surprise the general reader to learn that there are nearly seventy species of beetles in this country which are the parents of wire-worms : many of them, however, live in decaying trees, or under the bark ; and the number that affect our crops of corn, vegetables,

and flowers, is very limited." The beetles from which they spring, and into which they pass, are called *elaters*; and almost every farmer has an instinctive dread of these worms themselves. Yet not many of these persons know that the little long beetles called "skip-jacks," which jump when laid on their backs in a wonderful manner, lay the eggs which produce these mischievous devourers. The elaters, or skip-jacks themselves, feed only on flowers. The best account to be found of them is that by Mr. Curtis, who gives more hints for remedies than any other writer. The long time these wire-worms exist in their larva state, adds very much to the amount of mischief inflicted by them.

Generally speaking, the larva state is the one in which insects do most injury to corn; but Mr. Kirby mentions that the weevil devours it when housed in the granary, both in the *imago* as well as larva condition; and that a single pair of these insects will produce in one year about six thousand of their species.

Cereal plants are likewise attacked by larva of the willow moth, which consumes the grains of wheat and the seeds of grasses. Flies, also, of various kinds, lay eggs that give

birth to larvæ destructive to the several kinds of corn, when they appear in any considerable quantity. These flies have their ichneumons for checking their increase, in the same way as the midge described in a previous chapter. They do not, however, belong peculiarly to the wheat, and are therefore not legitimate subjects for this work, beyond a passing notice of their existence. Amongst the British flies, the one called *oscinis vastator* is much to be dreaded. Two broods of maggots are yearly ushered into life from its eggs. Those born in the summer are located between the sheath and stem, above the soil; those that are hatched in the autumn are close to, and perhaps below, the surface. These flies and their preventives are described in the papers before mentioned, which have been published by the Agricultural Society. One of the most remarkable flies which infest wheat and other grain, appears to be the *cephus pygmaeus*, or corn saw-fly. For a knowledge of the singular habits of this creature we are entirely indebted to Mr. Curtis. No farmer had previously discovered it, as far as is known; no Englishman of science had previously described its operations and habits. It is,

however, not a stranger to certain ingenious foreigners, who have noticed its ravages in the rye-fields of France, and have published accounts of it in the scientific annals of their country. The fly itself is about half an inch long, and black, with four transparent and iridescent wings; the legs are yellow, striped with black. Many of them may be frequently observed on flowers, in corn-fields, during June, and on grasses, in woods; but a casual glance at them gives no indication of their mischievous habits. The female lays her eggs just below the ear, in the straw of the corn-plant, and the larvæ travel from the top to the bottom, eating as they go, and working through the knots with perfect ease, until the time of the ripening of the harvest, when they eat through the stem near the ground, and pass into the chrysalis state. France has, at times, suffered extremely by the attacks of this singular insect, whose habits have hitherto been little known and less suspected by those whom they much concern in this country. Persons have now been led, by the light thrown on the subject through the papers of Mr. Curtis, to search for it; and an interesting communication appeared respecting it in the "Gardeners'

Chronicle" for February 21, 1846. It is stated in this periodical, that the maggots inhabiting the straws live through the winter, inclosed in transparent cases, of very close texture, and enter the pupa condition in March. It is also added by the correspondent of this valuable paper, that "these flies resort to flowers in corn-fields, grass in woods, and umbelliferous and composite flowers on banks and road-sides. The straws containing the larvæ may be detected after harvest by a little attention, the short pieces of stubble being cut horizontally by them. They undoubtedly cause serious mischief, as the ears of the infested stems are either sterile, or contain only a small number of shrivelled grains. Burning the stubble seems to be the best means of extirpating the cephus; but there is an ichneumon named *pachymærus calcitrator*, which keeps it in check by depositing eggs in the maggots, which hatch and live upon them."

There are many other little insects found on the stems and ears of the *cereal*ia, or corn plants, the habits of which have not yet been sufficiently inquired into, nor the actual services performed by others that accompany them. We have an example of this in the

thrips, as it is called, that Mr. Kirby described many years ago; but it ought to become the subject of fresh observations. This venerable naturalist took the orange powder in the ears for the excrement of the thrips. It was probably the *uredo rubigo* which he saw. The author found quantities of the *thrips* last autumn, (1845.) He has also found a great many this year, (1846.) The larvæ likewise of a fly called *chlorops* has this year attacked barley. In some instances the orange powder in the wheat appeared, and some not. Where it did appear, it was the *uredo* fungus just mentioned.

To say that wheat is subject to the presence of *aphides*, or plant-lice, is only to state in the case of wheat what may be affirmed of almost every known produce of our soils. The same may be likewise said of several other minute creatures that are found in the fields. In our granaries, besides weevil, the larvæ of a species of *tinea* make great havoc. Thousands of *acari* will be found in bran kept for any length of time. All these minute creatures, like the weeds, the thorns, and the briars, have been permitted to spring up; and in this our fallen condition we must count

upon "the years to be eaten by the locust, the canker-worm, and the caterpillar, and the palmer worm," which are "His great army," who rules over all things.

When alluding to the *vibrio tritici*, or eel of the wheat, it has been more than once stated that it belongs, properly speaking, to the class of animalculæ called infusorial, because they constantly appear in infusions of certain substances. The possessor of a tolerable microscope may soon convince himself of the truth of this assertion. Let him take a small glass vessel, a tumbler if he please, and place in it a little hay, and then fill it nearly full of rain water. When it has stood a few days exposed to the air, a slimy sort of matter will be seen floating on the surface; take a little of this off with a pointed feather, and put it on a slip of glass: use a quarter of an inch achromatic. A sight perfectly astonishing will now present itself: the little drop of water will appear a perfect mass of active life. Sour paste will also be found teeming with vibriones, or little eels of extreme activity. The author obtained the most active and curious eels he ever met with from an infusion of ripe strawberries in rain water; they darted about with

amazing quickness. Myriads of little black vibriones abound in almost all stagnant waters, and may be seen mingled with the other infusoria by taking a little of the scum in the way just recommended. Those who wish for acquaintance with the several forms these animalculæ assume, must consult writers on the subject, particularly the great work of Ehrenberg. Some of the most beautiful sights exhibited by the microscope, may be enjoyed by those who make various infusions with a view to observing these infusoria. Besides those mentioned, cabbage-leaves, sage-leaves, leaves of sea-kale, and other vegetables, make excellent infusions teeming with life. Like the sporules of fungi, their eggs are universally diffused, and hatch in any suitable place.

The forms of these infusoria are capable of the greatest possible variety. Some of them can hardly be said to have any well-defined figure, but are composed of a kind of gelatinous substance, having no solid framework, and so may be made to assume almost any kind of outline. Others are enveloped in shields or sheaths, which continue after the animalculæ themselves have long ceased to exist. Ehrenberg, believing that they are

provided with many stomachs, calls them *polygastrica*, from the Greek πολύς, (*polus*) and γάστηρ, (*gaster*) a stomach. If they are suffered to remain a short time in water containing finely divided particles of colouring matter, the appearance of these particles in their transparent bodies, is such as to indicate that they contain numerous globular cavities. Still this point cannot be regarded as completely decided; and by many persons the views of Ehrenberg are declared to be untenable.

Round the mouths of these animalculæ there are found *cilia*, moving with a rapidity that astonishes the observer: they look like hairs vibrating with a vehemence that is incredible till witnessed. This vibration produces currents in the fluid containing the infusoria, and thus the food on which they live floats into the mouth. At the same time, they are enabled by the cilia also to swim quickly about. Totally invisible to the naked eye, a good quarter of an inch achromatic presents them to the view of the microscopist in a little globule of water. "When," says an eminent physiologist, "a number of dissimilar forms are assembled in one drop of water, the spectacle

is most entertaining. Some propel themselves directly forward, with a velocity which appears, when thus highly magnified, like that of an arrow, so that the eye can scarcely follow their movements; whilst others drag their bodies slowly along, like the leech. Some make a fixed point of some portion of the body, and revolve round it with great rapidity; whilst others scarcely present any appearance of animal motion. Some move forwards by a uniform series of gentle undulations or vibrations; whilst others seem to perform consecutive leaps of no small extent compared with the size of their bodies. In short, there is no kind of movement which is not practised by these animalculæ: they have evidently the power of steering clear of obstacles in their course, and of avoiding each other when swimming in close proximity. By what kind of sensibility the wonderful precision and accuracy of their movements is guided is yet very doubtful. The general surface, in those whose bodies are not inclosed in a firm envelope, appears very susceptible of impressions. No organs of special sensation, however, can be detected, except certain red spots observable

in the bodies of many species, which are believed by Ehrenberg to be eyes."

The least and simplest of these infusoria are called *monads*, which generally are spherical in shape, and swim about with ease and rapidity. It is not, however, the object of this notice to trace the various families of infusoria, but by a few general observations to show their most prominent characteristics, and the singular analogy between them and the minute fungi brought before the reader in the foregoing parts of the volume. All geologists are acquainted with the quantities of fossil infusoria in chalk and other minerals, some of which contain them to an extent perfectly incredible, until proved by ocular demonstration. The mineralised skeletons actually in many cases have contributed to form solid strata of the earth. There is a kind of siliceous stone from Tripoli, which is completely made up of skeletons or sheaths of infusoria. A single cubic inch of bog iron ore contains about two millions of millions of microscopic animalculæ. Of the species of fossil infusoria thus discovered half at least still exist. In their dead state, and fossil condition, they doubtless con-

tribute to the growth of vegetable substances. We shall now see the wonderful functions they perform during life, for the benefit of us all.

These curious infusorial animalculæ are found living in all the stagnant waters with which we are acquainted. It may be truly said,—

“———where the pool
Stands mantled o'er with green, invisible
Amid the floating verdure millions stray.

Every fluid drop of the ocean contains them ; and they abound in mud.

Like the eels of the wheat again, some of these maintain a torpid existence, when dried up by the summer's sun ; and in this condition countless myriads of them are raised up with exhalations into the atmosphere. The *guano*, so extensively used for manure, is full of the most beautiful infusoria, some of them splendidly iridescent ; and there is no better method of testing the genuineness of this useful substance than by the microscope. A small portion of guano dust, viewed with a quarter of an inch achromatic, affords a surprising spectacle, as any one who pleases may prove. In short, the whole creation teems with life.

“Link after link the vital chain extends,
And the long line of being never ends.”

But it is impossible to conceive that infinite wisdom, and power, and goodness, can give vitality to such atoms without a direct and a beneficial design. Science has, indeed, recently had its reward in discovering such a design in the infusorial animalcules in their living state. "A wise arrangement of nature," says Liebig, "has assigned to the infusoria the dead bodies of higher orders of beings for their nourishment; and has in these animalculæ created a means of limiting to the shortest possible period, the deleterious influences which the products of dissolution and decay exercise upon the life of the higher classes of animals. The recent discoveries which have been made respecting these creatures are so extraordinary and so admirable, that they deserve to be made universally known." The principal fact in these discoveries is, that the functions of animal nature are reversed in these animalcules, and that instead of evolving carbonic acid gas, they evolve pure oxygen. Count Rumford made a similar discovery many years ago; but it was, like numerous other good facts, totally buried in oblivion. The air bubbles given out by water containing these animalcules contain such pure oxygen,

that a small bit of deal match-wood, in which a flame has just been extinguished, will burst into a flame again on being immersed in any one of them. "I myself," the celebrated German chemist last named tells us, "took an opportunity of verifying this remarkable fact, upon finding in a trough of water in my garden the fluid coloured green by the presence of various species of infusoria. I filtered it through a very fine sieve, in order to separate all confervæ, or vegetable matters; and then exposed it to the light of the sun in an inverted beaker-glass, completely full, the aperture of which was confined by water. After the lapse of a fortnight, more than thirty cubic inches of gas had collected in the glass, which proved to be very rich in oxygen." Here, then, we have actually in these creatures, unsuspected and unseen till the microscope revealed them, a source of pure vital air. From the instant, therefore, that these infusoria appear in stagnant water impregnated with deleterious matter, that water ceases to act injuriously on the higher orders of plants and animals. To quote Liebig once more: "In the most extensively diffused animalculæ, namely, the green and red infusoria, we recognise a most

admirable cause which removes from water all substances injurious to the life of the higher classes of animals ; and creates in their place nutritive matters for the sustenance of plants, and the oxygen indispensable to the respiration of animals." Again, he observes, "The infusorial animalculæ cannot be the causes of putrefaction—of the production of poisonous matter deleterious to plants and animals—but an infinitely wise intention designs them to accelerate the transition of the elements of putrefying substances into their ultimate products." The reason of their presence in these places as regards themselves obviously is, that in them they find the conditions suitable for their development and sustenance. When these circumstances take place, the universal presence of the atmosphere through which their eggs are diffused, causes them to make their appearance wherever the requisite state of things for their vivification exists. They are, however, subject to the injurious influences of actual putrefaction, and are killed by the sulphuretted hydrogen gas evolved during that process. They abound in all decaying substances, but never in really putrid masses. Their province, therefore, evidently is that

mentioned by Liebig, to hasten on decay, and limit the health-destroying influences of putrescent matters.

If a globule of water in which they are found is placed on a slip of glass under a microscope, they will, as has been said, be seen swimming about in it with extreme vivacity. Just take the least drop of sulphuric acid on some fine point, of a hair, or a pin, or a feather, and touch the water. They die instantaneously, as if suddenly shot. Nothing can be conceived more momentary than this effect.

The contemplation of such subjects must ultimately produce great changes in the process of man's thoughts. How often have we been disgusted in looking upon the red and green colouring matter of some pond or ditch, and regarded it as a nuisance. This view was, like many others in which we indulge, far from the truth. Instead of being what our imagination misrepresented to us, it was a world of beautiful and useful creatures performing unseen the great purposes of God, and actually conferring benefits on us who were regarding them in a wrong light. The remembrance of the errors of ignorance ought to humble us ;

and while nature is daily opening the treasures of her hidden marvels, we ought to learn that revelation can unfold greater marvels still, to rebuke our trust in feeble sense, and quicken our faith. It is hoped that the remarks in this chapter on the fungi and insects that may be regarded as the congeners of those it was the chief object to describe, will give an increased interest to the details before given. They may tend also to the good of the agricultural reader, by God's blessing, in more ways than in pointing out certain mundane evils and their remedies. It is desired that they may beget in his mind many considerations to which, perchance, he may heretofore have been a stranger. Lessons of piety are not only written in the gospel, but those lessons we find there, are enforced by a right knowledge of nature. The natural and moral perfections of God are in perfect unison; and we may be certain, that as science advances in Christian lands, its discoveries will help to close the lips of the sceptic, and the true light brightening at the same time, "wisdom and knowledge" will indeed become both the "stability of our times, and the strength of our salvation."

In order, however, that this happy result may accrue, it is necessary not merely that we should view nature in the great and the small, with admiration of the power and wisdom of the Creator, but that we should see physical truth through a spiritual medium. Ages past, the heathen poet could say of the great Supreme Cause, "In him we live, and move, and have our being." In the same manner we may say now with our own—

Hail, Source of Being! Universal Soul
Of heaven and earth! Essential Presence, hail!
To thee I bend the knee; to thee my thoughts
Continual climb; who, with a master hand,
Hast the great whole into perfection touched.
By thee the various vegetative tribes,
Wrapt in a filmy net, and clad with leaves,
Draw the live ether, and imbibe the dew.
By thee dispersed into congenial soils,
Stands each attractive plant, and sucks, and swells,
The juicy tide; a twining mass of tubes.
At thy command the vernal sun awakes
The torpid sap, detruded to the root
By wintry winds; that now in fluent dance,
And lively fermentation, mounting, spreads
All this innumerable coloured scene of things."

This is all true, and beautifully expressed; but more is required. And as the present mixed state of the world is unquestionably declared in Scripture to be due to the fall of its principal inhabitant, so everything natural,

to be profitably regarded, must be referred more or less to the moral condition of man in this world. We shall then find nature and religion helpful to each other. The religion of Christ is the only rectifier of that which is wrong in nature ; and nature in her turn, by her analogies, strengthens man's faith in religion. Our Lord himself in his ministry taught much by natural similitudes, and has hereby left his servants a pattern they should more largely follow. If the thorn, and the brier, and the various impediments to the earth's bringing forth the needful sustenance for man, have succeeded the curse, then it is but reasonable that our studies of these disorders of the original beauty of creation should be made with the aid of revelation. It is true that the gospel was not designed to teach us physical science, but it was intended to explain and rectify our condition, and to unfold to us the relation wherein we stand to God, both for time and eternity. But considering that the effects of this our state prevail all over nature, and will be the ultimate cause of the destruction of the world, it is quite clear that the Scriptures, though not teachers of science, must be the regulators of those who pursue it

aright. "The wisdom of this world," arising out of the mere exercise of our rational faculties, is plainly asserted to be "foolishness with God."

"Truths that the learn'd pursue with eager thought,
Are not important always, as dear bought,
Proving at last, though told in pompous strains,
A childish waste of philosophic pains.
But truths, on which depend our main concern,
That 'tis our shame and misery not to learn,
Shine by the side of every path we tread
With such a lustre, he that runs may read."

Without some allusions to the causes which involved the world in its present anomalies, all things around us are a mystery. Viewed through the gospel, they are seen to be parts of a peculiar whole, and the reason is explained; while both in the evils which attend our minds, and those which spread over the face of all things, we may perceive the same mixture of justice, mercy, and instruction. Not one of the minute consumers of our food which have been adverted to in these pages will, thus regarded, fail to teach us some lesson. The very atmosphere we breathe has been shown to be pregnant with the germs of these little pests; and yet tried as we are by them, they all perform some compensating function, which shows that in the very midst of judgments

there is in heaven a remembrance of mercy. Is not this what revelation teaches us in a higher degree? And do we not see an analogy in the universal diffusion of these atoms, having life and giving birth to living things that prey on that which we regard the most valuable, to the whole state of the moral atmosphere around us, whence sins of all kinds enter the heart upon the wings of every thought? Look again at the mistakes made respecting these pests. How continually have they been misconstrued; and let us remember how little man knows without the gospel, of the real character of the miseries which beset him in this life. It has been mentioned that certain cultivators of the soil have regarded some of their little foes as a favourable sign, accompanying a good yield of a valuable produce. How many are continually making similar errors with regard to the destroyers of that which is for their highest interest. Multitudes of people look upon certain irregularities in youth, for instance, as signs of what they call a good heart, a free disposition, a manly generous spirit; and believe them to be compatible with an abundant exhibition, in after-life, of virtues of various kinds. But they forget that

they are really destructive of all that fits the heart for the knowledge of God, and true preparation for his presence hereafter. Again, we have shown how constantly men have attributed to the destroyers of certain insects, the very evils caused by these little depredators to which they are the antidotes. This has been done in ignorance, and knowledge has shown the error. Now, how constantly do we find persons attributing to the very individuals who are aiding by their counsels, their prayers, and examples in warding off evils, the actual evils themselves. All sorts of misrepresentations of Christian agency, every species of opprobrious epithet, all kinds of denunciations have been levelled against those whose occupation is in presenting the only genuine antagonism to the spread of all that would overrun and destroy the best blessings of man. Blind prejudice has constantly accused such philanthropists of causing the maladies to which, under God, they are the only effectual check. Perhaps some persons who have indulged in such mistaken views, may learn from these observations to make more assiduous inquiries, and to seek for light and knowledge. "There is a

way that seemeth right unto a man, but the end thereof are the ways of death."

Many more instructive analogies might be adduced. We may recollect that not a single devastator of our bread-corn; not a single insect to which attention has been called; not a fungus that preys upon and accelerates the decay of the most useful plants, but in its nature has a tendency to remove, as well as to inflict, some evil. We have seen how it is their province to hasten decay, limit putrefaction, and thus to promote health. And ought we not to mark the effect of trials on the Christian? What is the tendency of everything which causes the man of the world to despair when overwhelmed by adversities? It is to purify the pious mind, to promote its health, to wean it from all that is prejudicial to its real welfare. So our afflictions "work out for us a far more exceeding and eternal weight of glory." Hereby Christian graces are called into exercise; patience has its perfect work; and it becomes actually good for us to have been afflicted. Is there not in these dealings of the supreme Governor of the universe with the natural and spiritual, the mark

of the same hand? Surely there is; and faith may learn to see the same God in both. No doubt there are men of science who may reject such inferences, and declaim against appending such notions to the details of physical research; but the Christian sees otherwise, and receives from all the incidents he meets with a different impression.

In reviewing the various diseases to which our best cultivated plants are subject, we have seen that there is not a cause of any one of them to which there is not some antagonism provided. These considerations lead us, by analogy, to look for some such provision against the diseases of the heart. We find it in the revelation of mercy God has made to man. There is only this difference, that while the antidotes to the pests which injure the fruit of our labours in the soil are as numerous as the pests themselves, the great remedy for all our moral miseries is but one, but that one is capable of every conceivable modification to suit the necessities of every case, and the wants of every age of the world. We may also remark that the analogy goes further. While the provision of natural antidotes does not preclude the exercise of human art to lessen the

numbers of the destroyers of our food, neither does the great provision of the gospel hinder the agency of man, and the diligent use of means. On the contrary it encourages them, provided only that they be in entire subserviency to the one great principle, and confidence in the efficacy thereof, under whatever form we present our modes of action to the objects we design to effect. Supreme confidence in the great remedy does not in any degree manifest itself by cessation from activity, but it rather signifies upon what grounds we may most effectually exert ourselves to do good. And in nothing does the wisdom of God in Christ more abundantly appear, than in accommodating this beautiful law of action not only to this or that particular society of men, but to the benefit of all mankind in all the variety of climates, countries, and habits in which they may be found. If he had framed this method of counteracting evil and restoring the lost happiness of man for one nation alone, it would have been an evidence of a particular wisdom, but in the suitability of the gospel to ameliorate the present state, and secure the future bliss of his fallen creature in all lands where the gospel comes, he has exhi-

bited an infinite and universal wisdom. Thus there is no true Christian who, by the exercise of the opportunities God has given him, may not help to bring in a revenue of glory to his Saviour, and a harvest of profit to his fellow-men.

The author, then, in conclusion, would commend these thoughts to the serious consideration of his readers. Long have great moral diseases consumed the best fruits of many portions of our land. We have thought too much of reaping the produce of the labours of men's bodies, and have regarded too little the serious account to which we must be called for our neglect of the one great remedy of their souls. While the farmer looks upon the rural population in his fields, tilling the soil, reaping the golden corn, or gleaning the ears that have fallen from the sickle, may he think on the duty of marking well the real destroyers of the happiness of our cottages, and diligently strive, by example, advice, and influence, to diffuse amongst them a love of that knowledge which can alone lead to an acquaintance with, and a true correction of, the ills which have long prevailed amongst thousands of the peasantry of this country. How anxious are

all the cultivators of the fields that they may be white to the harvest, and free from the defects engendered by such causes as those we have described. They are willing to try every species of corrective, and to apply every possible remedy. But let us recollect that there is such a thing as a spiritual harvest, and that we are suffering it to become infected by negligence of that which has been so mercifully provided for its beauty while growing, and purity when gathered into the Lord's garner, into which the wheat is to be taken, while the chaff is to be burned up with unquenchable fire. Men having possessions are stewards for God, and are as much responsible for their moral efforts amongst those who labour in these possessions, as the employed are for their diligence in the tasks meted out to their hands. Suppose a man to whom the seed for a large farm was entrusted, had omitted to dress it, and, in the time of reaping, the ears were found, to a great extent, destroyed by the nauseous fungus which replaces the flour. Whose would the responsibility be? Will not a like solemn day of account come for those who have influence over men of low estate, and neglect to regard the culture of their minds, and to sow amongst them, in all

possible purity, the seeds of that truth which is essential to salvation?

These remarks, it is trusted, will be regarded as natural inferences from the subjects before the reader. Desirous to communicate knowledge to the farmer, the author cannot forget his higher calling as a minister of the word of life, and he is one of those who believes that science may be made a fitting channel for conveying occasional hints upon the greater verities of the gospel. The wisdom and goodness of God which shone in weaker rays in the morning dawn of nature, break forth with stronger beams in the scheme of redemption, now that the Sun of righteousness has risen with healing in his wings, and the day hath appeared. We, then, should live as children of the day; and we should remember that we see the things of creation, as the key of knowledge opens them to our view, not in the light of early morn, before the mists had begun to melt, but with the advantages of those on whom the true light shineth. There is not a thing so small, so mean, or so low, as to be incapable of reflecting some beam of this light, not merely for the expansion of our intellectual faculties, but for the in-

struction of our spirits, affording rich matter not only for our heads, but our hearts. The grace of God does not destroy nature, but elevates it ; so the fuller discoveries of the wisdom of redemption quicken the admiration of the eye that rests upon the works of the Divine hand below ; and never did the psalmist send forth sweeter notes, prophetic of the Saviour, than when he had previously dilated on the perfections of God as the framer of the world, and all species of creatures. With him we may well say, “O Lord, how manifold are thy works ! in wisdom hast thou made them all !”

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